AFIT\GEE\ENV\94S-25

STATUS OF STORM WATER POLLUTION IN THE UNITED STATES

THESIS

Lynne A. Urquhart, B.S.

AFIT\GEE\ENV\94S-25

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

AFIT\GEE\ENV\94S-25

STATUS OF STORM WATER POLLUTION IN THE UNITED STATES AIR FORCE

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Engineering and Environmental
Management

Lynne A. Urquhart, B.S.

September 1994

Acknowledgments

In writing this thesis I have had a great deal of help from others. First I would like to thank the members of my thesis committee. My faculty advisor, Lt Col Joe Amend, provided support and guidance in developing this study. He spent many hours working with me to direct my efforts. My reader, Dr. Charles Bleckmann, provide expertise in biology and research and assistance in defining this study and editing my work. These two gentlemen kept me focused on what I needed to do. I would also like to thank my father, Col Gerald Adams, for acting as a sounding board for all my ideas and providing a headquarters' view of my research. I wish to thank all the personnel at the bases that provided information, without which this research would not have been possible. And finally, and most of all, I wish to thank my husband Eldridge for his understanding and patience in dealing with our long separation.

Table of Contents

List of Figures

List of Tables

Abstract

The purpose of this study was to determine the status of storm water pollution in the United States Air Force (AF). This is important since most AF bases are now required to have applied for a National Pollutant Discharge Elimination System (NPDES) storm water permit. The objectives of the study were to: evaluate the sampling rates used at AF bases; determine the pollutants tested for by the AF bases; compare the pollutant concentrations of the AF bases to an Environmental Protection Agency (EPA) water quality standard; and determine if there were any trends in sampling or pollutant concentrations due to seasonal changes or across AF Major Commands or EPA Regions. This was done by requesting data from eighty-one AF bases in the United States. Data was received from fifty bases.

It was determined that fifty-four percent of the responding bases had no storm water sampling programs. In order to meet permit requirements, the bases will need to sample at least 4 times during the winter, deicing, months.

Only three pollutants (oils and grease, pH, total suspended solids(TSS)) were sampled for by most bases with a storm water sampling program. Bases will need to sample for, at a minimum, pH, TSS, biological oxygen demand (BOD),

and chemical oxygen demand (COD) to meet permit requirements. In addition, bases will need to sample their storm water on a quarterly basis for a year to characterize their storm water pollution.

The AF has a problem with its storm water. There were seventeen pollutants for which the AF was evaluated. One pollutant (Total Kjeldahl Nitrogen) is not a problem, four of the pollutants (pH, lead, phosphorus, and TSS) present a problem only at individual bases, and the other twelve pollutants are significant problem for the AF. The AF data exceeded the bench mark values for the other twelve pollutants at rates ranging from thirteen percent for aluminum up to ninety-six percent for copper. There were no trends in pollutant concentrations across EPA Regions. The only trend across the AF commands was that Air Combat Command is the only command with lower a percentage of data exceeding the bench mark values than the AF as a whole for most pollutants.

STATUS OF STORM WATER POLLUTION IN THE UNITED STATES AIR FORCE

I. Introduction

This chapter describes the purpose and specific questions answered by this study. It contains current information on the Clean Water Act (CWA), specifically the storm water regulations, and explains how they impact the Air Force (AF). This chapter also defines the limitations of this study and presents an overview of the following chapters.

Background

The CWA was passed in 1977 to protect the waters of the United States (U.S.) from pollution. Originally the emphasis of the CWA was the control of point discharges, such as the effluent of a wastewater treatment plant. This was done using the National Pollutant Discharge Elimination System (NPDES), described in Chapter II. As point source discharges were brought under control, the focus of the CWA shifted to nonpoint source (NPS) pollution.

"Nonpoint sources of pollution account for more than 50% of the total water quality problem,..." (Novotny, 1981:2). They have caused "environmental damage in 76 % of

impaired [polluted] lakes, 65 % of impaired stream miles, and 45 % of the square miles of impaired estuaries ..." in the U.S. (Roy, 1991:66). Storm water generates NPS pollution by becoming contaminated with pollutants as it travels over the earth's surface. An amendment to the CWA was passed in 1987 requiring the Environmental Protection Agency (EPA) to regulate storm water discharges under NPDES.

Prior to the 1987 amendment, regulation of storm water discharges was limited. This amendment established the National Storm Water Program, which was divided into two phases. Phase One, which is currently being implemented, required regulation of five categories of discharges, including discharges associated with certain industrial activities. AF bases usually have, at a minimum, industrial activities related to air transportation and motor transportation facilities that are regulated under the new legislation. Phase Two requires the EPA to designate additional storm water discharges to be regulated based on the results of studies conducted in Phase One.

The AF applied for coverage under a group storm water permit. It is now expected to receive permit coverage under a general permit, the "NPDES General Permit for Storm Water Discharges From Industrial Activities." This permit was published in the Federal Register in draft form on November 19, 1993 (USEPA, 1993c). It will directly cover only those bases in states without the authority to issue NPDES permits

(Table 6). However, most other bases will be indirectly covered by this permit, since most states will adopt this permit with few changes. All AF bases should be preparing to meet, at a minimum, the requirements defined in this permit. Included in the fact sheet that was published with the permit were bench mark values for some pollutants (Table 8). While these values are not effluent limitations for storm water, they can be used to determine if the AF is endangering people and if an effort may be required to meet the bench mark values. Previous to this research there has not been an evaluation as to whether the AF is meeting these bench mark values.

Thesis Objectives

The purpose of this study is to examine current storm water sampling and testing practices on AF bases and determine if the AF is putting itself at risk with these practices. In other words, are these practices adequate for the AF to evaluate its storm water in order to determine if that storm water is or could be endangering the environment? This study also evaluates whether the bases are exceeding the bench mark values, using current storm water pollutant concentrations from the bases. The following questions will be addressed:

(1) How often is storm water sampled?

(2) What pollutants are the samples tested for?

(3) What are the current regulatory requirements for storm water?

(4) What concentrations of pollutants are in the storm water?

(5) Are there any trends in testing or exceeding the bench mark values across the AF, the AF major commands (MAJCOMs), or the EPA regions?

These questions are used to focus the study.

Limitations

There were two areas in this study where assumptions were made. The first area was the quality of the data used in this study. The data, supplied by the individual bases, was not evaluated for accuracy. There was no investigation of the sampling techniques used for collecting the storm water samples. This has been addressed in previous research efforts, Guidance For The Development of Air Force Storm Water Sampling Programs by Jerry Weldon and Roy Willis. In this present research there was no evaluation made on the quality of the testing laboratories used to analyze the data or whether it was analyzed according to the latest EPA testing procedures. Results provided by the base environmental flights or bioenvironmental offices were assumed also to be accurate. Additionally, if the person contacted stated there was no historical storm water

sampling data for that base, this result was also used in this study.

The second area where assumptions were made was regarding the draft of the "NPDES General Permit for Storm Water Discharges From Industrial Activities." This draft permit is treated as the final copy for purposes of this study. The bench mark values provided in the fact sheet accompanying this draft are assumed to be an accurate reflection of current research and to be the EPA recommended ambient water quality criteria.

Overview

Chapter II contains the literature review, which provides the background of this study. Chapter III contains the methodology that describes what data was collected and how the data was evaluated. It also contains the results of the analysis. Chapter IV contains the conclusions drawn, based on the results of the analysis, recommendations for the AF in the future, and recommendations for future research. Appendices contain the initial request for information sent to the bases, data tables and definitions of acronyms and abbreviations.

II. Literature Review

Introduction

In order to examine the current storm water sampling and testing practices on AF bases and the rate the bases exceed the EPA's bench mark values, it is necessary to understand NPS pollution: what it is, where it comes from and how it impacts the environment. It is also important to understand what the current storm water regulations are, where they came from and what impact they have on the Air Force. This can be accomplished by examining the current literature on NPS pollution and storm water regulation and interviews with experts in the relevant fields.

Pollution

Pollution is a change in the physical, chemical, or biological characteristics of air, land, or water that is judged by man to have undesirable consequences (Alexander, 1976:3-5). One example of pollution would be the release of large quantities of sulfur dioxide into the atmosphere. This could be from a natural source, for example a volcanic eruption, or a man-made source, such as a copper smelter. Sulfur dioxide in quantities as low as 0.07 parts per million parts per million (ppm) in air can aggravate chronic respiratory disease in children (USEPA, 1981). Both natural and man-made sources of pollution may significantly effect

the environment, but effort to control pollution is limited to those sources for which man is responsible.

Nonpoint Source (NPS) Pollution.

Pollution can be divided into two categories by source: point source and nonpoint source. Point source pollution originates from a single concentrated source, such as an industrial smoke stack or municipal sewage treatment plant's effluent pipe. NPS pollution is defined as all pollution that is not generated by an identifiable point source. NPS pollution originates over a dispersed area rather than a concentrated area.

Example. An example of NPS air pollution is that generated by vehicles. One car does not generate enough exhaust gases to be detrimental to the atmosphere, but all the vehicles in this country combined contribute 900,000 metric tons per year of sulfur oxides to the atmosphere (Goddish, 1991:29). NPS air pollution is obvious in areas like Los Angeles, California, with its smog problems.

NPS Water Pollution. The focus of this study is NPS water pollution, hereafter referred to simply as NPS pollution, which originates from the processes described below. When precipitation, falls as rain, sleet, or snow, on the earth's surface at intermittent intervals, it is classified as storm water. It then travels across the earth's surface under the influence of gravity as storm

water runoff, snow melt runoff, surface runoff or drainage, until it reaches a body of surface water (a lake, river, or wetland) or seeps into the ground water. As the water travels over the earth's surface, it can become contaminated with pollutants, such as those listed in Table 1 or Appendices A or B. The pollutants can be transported by storm water in three ways: (1) dissolved in the storm water; (2) suspended in the storm water; or (3) adhered or absorbed to some other substance in the storm water (Wilmer, 1992:127).

Example. Consider the process involved in the creation of NPS pollution resulting from the use of fertilizers in agriculture. Fertilizers containing

Table 1 Conventional Pollutants
Biological Oxygen Demand (BOD)
Chemical Oxygen Demand (COD)
Total Suspended Solids (TSS)
Total Kjeldahl Nitrogen (TKN)
Nitrate and Nitrite as Nitrogen (N+N Nitrogen)
Oil and Grease (O&G)
Total Phosphorus (P)
pH
(USEPA, 1993a:61168)

nutrients, phosphorus and nitrogen, are applied to cultivated fields. Later, a quantity of these fertilizers can be carried away, by precipitation or irrigation, to a nearby surface water body, such as a lake. The nutrients are consumed by the algae populating the lake. The algal population increases, resulting in an increase of both living and dead biomass. The dead biomass creates an oxygen demand in the lake as it decomposes, reducing the dissolved oxygen available to other aquatic life. This may result in the death of other organisms, such as fish, by suffocation.

In this example of NPS water pollution, the process starts with precipitation becoming contaminated due to man's activities as it travels over the earth's surface. When the runoff reaches a body of surface water it can negatively impact the environment by degrading the quality of aquatic life.

Impacts of NPS Pollution

There are six categories of pollutants generated by storm water runoff: sediments, pesticides, nutrients, toxics, pathogens, and oxygen demanding wastes. The first five of these pollutant categories and their water quality impacts are given in Table 2.

Sediments negatively impact water quality in several ways: aquatic organisms are smothered, fish respiration is

Table 2
Water Quality Impacts From Nonpoint Pollutants

Pollutants	Water Quality Impacts
Sediments	• Decrease the transmission of light through water • Direct respiration and digestion effects on aquatic life • Decrease in viability of aquatic life. • Increase in temperature of surface layer of water • Decrease in value for recreational and commercial activity • Increase in drinking water costs • Examples include sand, silt, clay and organic materials
Pesticides/Herbicides	• Hinder photosynthesis in aquatic plants • Lower organism's resistance and increase susceptibility to other environmental stresses • Can kill non-target species • Can bio-accumulate in tissues of fish and other species • Some are carcinogenic and mutagenic and/or teratogenic • Reduce commercial/sport fishing and other recreational activities • Health hazard from human consumption of contaminated fish/water
Nutrients	• Eutrophication, or "promotion of premature aging of lakes and estuaries" • Nitrates can cause infant health problems • Reduced oxygen levels can suffocate fish species • Interference with boating and fishing activities • Eliminated submerged aquatic vegetation and destroy habitat and food source for aquatic animals and waterfowl
Metals (Toxics)	• Accumulate in bottom sediments, posing risk to bottom-feeding organisms • Bio-accumulate in animal tissues • Affect life spans and reproduction rates of aquatic species • Affect water supplies and recreational and commercial fishing
Pathogens	• Introduce disease-bearing organisms to surface waters • Reduce recreational uses • Increase treatment costs for drinking water • Human health hazard (USEPA, 1984:1-10,1-11)

impaired, plant productivity is reduced, and human aesthetic enjoyment of the water is reduced. (EPA, 1994:7)

Pesticides include "a range of chemicals that kill organism that humans consider undesirable" (Masters, 1991:114). They include insecticides, herbicides, rodenticides, and fungicides. "These pollutants are generally very persistent [last a long time] in the environment and may accumulate in fish, shellfish, and wildlife to levels that pose a risk to human health and the environment" (EPA, 1994:8).

Nutrients are chemicals that are essential for living organisms to grow (Masters, 1991:110). Examples of these chemicals are nitrogen, phosphorus, carbon, sulfur, calcium, potassium, iron, manganese, boron, and cobalt. Nitrogen and phosphorus are the nutrients required in the greatest quantity and are therefore usually the limiting factors in growth of organisms. Therefore when a large quantity of nitrogen or phosphorus is introduced into a body of water it commonly leads to excess growth of aquatic plants. This growth results in larger quantities of decomposing plants that reduce the dissolved oxygen levels in the water body and may endanger aquatic life.

Toxics are generally heavy metals or organic chemicals that have a wide range of adverse effects on human health. These substances may cause "disease, physiological malfunctions, behavioral abnormalities, birth defects, or

death in organisms that ingest or adsorb" them (Ember, 1992:21). They are generally very persistent in the environment (EPA, 1994:8).

"Pathogens are disease producing organisms that grow and multiply with in a host" (Masters, 1991:108). They can produce a wide range of diseases in humans, from minor respiratory and skin diseases to typhoid and dysentery (EPA, 1994:7). Examples of pathogens are bacteria, protozoa and parasitic worms.

Oxygen demanding wastes are substances that oxidize and as a result reduce the dissolved oxygen in water (Masters, 1991:107). Saturated oxygen levels, for water, range from eight to fifteen milligrams per liter (mg/L) of dissolved oxygen. The minimum oxygen levels, that will support aerobic life, range from less than three to eight mg/L, or saturation. This is a fairly narrow range and a very slight increase in oxygen demand can deplete the dissolved oxygen available in a body of water. There are two types of oxygen demanding substances: biological oxygen demand (BOD) and chemical oxygen demand (COD). BOD is the oxygen consumed by microorganisms to biologically degrade wastes. COD is the oxygen consumed by the wastes during chemical oxidation (Masters, 1991:108).

Table 1 and Appendices A and B list pollutants of concern in storm water. Table 1 contains the conventional pollutants to be sampled for in the "NPDES General Permit

for Storm Water Discharges From Industrial Activities." Appendix A contains the toxic and hazardous pollutants and Appendix B contains the water priority chemicals to be identified by a storm water discharger if expected to be present.

Sources of NPS Pollution

The pollutants listed in Table 1 and Appendices A and B originate from a variety of sources.

> Pollution from diffuse sources can be related to weathering of minerals, erosion of virgin lands and forests including residues of natural vegetation, or artificial or semiartificial sources. The last can be related directly to human activities such as fertilizer application or use of agricultural chemicals controlling weeds or insects, erosion of soil materials from agricultural farming areas and animal feedlots, construction sites, transportation, cumulating of dust and litter on impervious urban surfaces, strip mining and others (Novotny, 1981:6).

The primary sources of NPS pollution are agriculture, mining, silviculture and urban runoff. Agriculture is the most significant source of NPS pollution impacting fifty to seventy percent of the nation's waters (USGAO, 1990:8). It is caused by soil erosion from croplands and over grazing and from pesticide and fertilizer application. Mining NPS pollution impacts one to ten percent of the nations' waters and is generated by abandoned mines, improperly sealed wells, and mining waste piles. Silviculture, or timber harvesting, impacts one to five percent of the nations

waters and generates sediments due to habitat alteration and access roads

Urban runoff impacts eleven to twenty-four percent of the nation's rivers and lakes (EPA, 1994,13,16), but it is very toxic to the environment. Urban runoff is generally classified as coming from industrial or residential and commercial areas. Residential and commercial areas contribute heavy metals, fecal coliforms, pesticides, suspended solids, and nutrients to storm water (El-Naggar, 1992:15). Industrial facilities contribute the same pollutants as the residential and commercial areas above, plus other pollutants based on the nature of the industry, types of processes in operation and the raw materials used (El-Naggar, 1992:15). Since this study is focused on the AF and the regulation of industrial storm water, only urban NPS pollution will be explored in detail.

Legislative Background

It is important to know the history of legislation for water pollution control and to understand that this legislation is continuously evolving. "The water pollution regulatory framework is the product of many years of historical development" (Arbuckle, 1993:151). Table 3 shows the major historical milestones in federal water quality legislation for surface waters. The first law, the River and Harbors Act or 1899, was enacted to assure that U.S.

Table 3
Major Milestones in Federal Water Quality Legislation for Surface Water

Rivers and Harbors Act	1899	Prohibited discharge of refuse into waterways that would interfere with navigation without a permit from the U.S. Army Corps of Engineering
Water Quality Act	1965	Required states to develop state water quality standards for interstate waters, and created the Federal Water Pollution Control Administration to establish broad guidelines and approve state standards Increased federal financial assistance for municipal wastewater treatment facilities
Federal Water Pollution Control Act Amendments	1972	Greatly increased federal financial assistance for municipal wastewater treatment facilities Instituted uniform technology-based effluent limitations for industrial dischargers and a national permit system for all point source dischargers Designated the U.S. Army Corps of Engineers as the permitting authority over discharge of dredged or fill material into U.S. waters
Clean Water Act	1977	Encouraged states to accept delegation of the national permit system and assume management of the construction grants program Added control of priority toxic pollutants to the federal program
Water Quality Act	1987	Phased out federal grants for construction of municipal wastewater treatment facilities; provided capitalization grants to state revolving funds Required EPA to develop regulations for stormwater runoff control Required states to prepare nonpoint source management programs (A National Water Agenda for the 21st Century, 1992:3)

waters were navigable. Further legislation was enacted, but it was not until 1965 that another attempt, the Water Quality Act, was made to regulate discharges to U.S. waters. This attempt at controlling water quality was unsuccessful in most states (Arbuckle, 1993:151).

Clean Water Act of 1972

Description. The Federal Water Pollution Control Act Amendments of 1972 (renamed the Clean Water Act in 1977) initiated modern water pollution control regulation. Its objective was "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." The law was based on the following principles: (Kovalic, 1987)

(1) No one has a right to pollute the waters of the U.S. Anyone discharging pollutants must have a permit.

(2) Permits limit the composition and pollutant concentrations of a discharge.

(3) All permits require specified controls based on cost and technology.

(4) Some permits require more rigorous controls based on receiving water quality.

The basic components of the law, used to meet these principles, were: the industrial effluent standards, water quality standards, regulation of toxic pollutants, NPDES, grants for publicly-owned treatment works (POTWs), the

pretreatment program and Spill Prevention, Control and Countermeasure Program (SPCC) (Air & Water Pollution, 1992:CWA-1).

NPDES. The NPDES permit program initiated under the 1972 CWA is the basis for storm water control. This program "requires the EPA to set limits on the amount of specific pollutants that may be discharged by municipal sewage treatment plants and industrial facilities" (Ember, 1992:21). These limits are incorporated into permits that are issued to the dischargers. It is illegal for these facilities to discharge without a permit.

Storm Water Under CWA "The Clean Water Act [of 1972] originally required control all storm water discharges" (Dodson, 1994:1-3). However, confusion over how to regulate these discharges got the program off to a slow start.

> Although the system of effluent limitations imposed through the NPDES permit program is an effective means of regulating water discharges which ... are amenable to treatment prior to discharge, this system is inappropriate means of regulating and controlling ... discharges, which ... are not subject to confinement and treatment (for example, area-wide or plant site runoff). (Arbuckle, 1993:191)

In 1973, the EPA issued regulations requiring storm water permits of certain "significant contributors" of pollutants under the NPDES program. By attempting to regulate storm water discharges under the NPDES program, the EPA was treating them as point sources. Later, when the regulations were challenged in court over the arbitrary designation of

"significant contributors", a U.S. District court ruled that the EPA must require permits for all point source discharges of storm water. As a result, a comprehensive storm water permitting system was not developed until the Water Quality Act of 1987 was passed.

Water Quality Act of 1987

Description. The Water Quality Act of 1987 required new regulations for controlling NPS pollution. This was due to two reasons. The first was the problems with establishing storm water control under the previous legislation. The second was that as point sources of water pollution were brought under control it became apparent that NPS pollution was widely contributing to the remaining water pollution problems.

Storm Water Program. The Water Quality Act of 1987 established the National Storm Water Program. Table 4 describes the two phases of this program and lists the events leading up to it. The Phase I regulations implemented a new approach to the control of storm water. Due to the delays in implementing Phase I, Phase II has been pushed back and the EPA is not expected to issue Phase II regulations before October 1997 (Dodson, 1994:1-3).

Phase I requires NPDES permits for four categories of storm water discharges. These are discharges issued a permit prior to February 4, 1987, discharges associated with

Table 4
Storm Water Fact Sheet

1972	Federal Water Pollution Control Act requires National Pollutant Discharge Elimination system (NPDES) permits for all point source discharges to water.
1973	EPA issues regulations requiring permits only for storm water contaminated by industrial or commercial activity. Point source discharges of "uncontaminated" storm water are exempt unless "significant contributors" or pollution.
1975	Court of Appeals remands 1973 regulations holding that permits are required for all point source discharges of storm water.
1987	The Clean Water Act (CWA) is amended to require EPA to establish a phased program to address storm water discharges.
Phase I	Prior to October 1, 1992, NPDES permits are prohibited for discharges composed entirely of storm water, except · Discharges that were issued a permit prior to February 4, 1987. · Discharges associated with industrial activity. · Discharges from medium and large municipal separate storm sewer systems (systems serving a population of 100,000 or more). · Discharges designated by EPA or an NPDES State as a significant contributor of pollutants or contributing to the violation of a water quality standard. Deadlines for EPA to issue permit application regulations, for dischargers to submit applications, and EPA or NPDES States to issues permits are established. Best Available Treatment (BAT) and water quality-based requirements apply to permits for storm water discharges associated with industrial activity. Permits for discharges from municipal separate storm sewer systems: (1) may be issued on a system wide basis; (2) must effectively prohibit non-storm water discharges; and (3) must control pollutants to the Maximum Extent Practicable (MEP), including compliance with water quality standards.
Phase II	EPA must conduct two studies of storm water discharges not covered under Phase 1. Prior to October 1, 1992, EPA must issue regulations which designate additional storm water discharges to be regulated to protect water quality and establish a comprehensive program to regulate such discharges. The program shall, at a minimum: A. Establish priorities. B. Establish requirements for State storm water management programs. C. Establish deadlines. The program may include performance standards, guidelines, guidance, and management practices and treatment requirements. (Bromley, 1992)

industrial activities, discharges from medium and large municipal separate storm sewer systems, and discharges designated by the federal or state EPA as a "significant contributor" or as contributing to the violation of a water quality standard. In Phase I "Instead of the end of the pipe, "test and treat" approach, the regulations focus on controlling pollution at its source" (Chinn, 1993:40).

Industrial Activities. All AF bases have at least one industrial activity in the categories regulated making it, of the four types of storm water discharges regulated, the one of most concern to the AF. This study will limit itself to discussion of storm water discharges associated with industrial activities. These discharges include but are not limited to: (Arbuckle, 1993:194).

(1) industrial plant yards;
(2) immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste materials, or by-products used or created by the facility;
(3) material handling sites;
(4) refuse sites;
(5) sites used for the application or disposal of process waste waters;
(6) sites used for the storage and maintenance of material handling equipment;
(7) sites used for residual treatment, storage, or disposal;
(8) shipping and receiving areas;
(9) manufacturing buildings;
(10) storage areas for raw materials, and intermediate and finished products; and
(11) areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water.

Industrial Classifications. The industrial activities required to have permits are classified by Standard Industrial Classification (SIC) Code or by a narrative description. These two methods of identification have differing permit requirements. Industrial facilities identified by SIC code are required to obtain a permit only when the primary site activity is within the SIC codes listed. "If the listed activity is not the primary site activity, it is considered an auxiliary activity which does not require permit coverage" (Dodson, 1994:2-7). Industrial activities identified by narrative description require permits if any of the described activities occur at the facility.

Table 5
Standard Industrial Codes Used In
AF Group Storm Water Permit Application

SIC Code	Title
0421	Trucking and Courier Services, Except Air
3721	Aircraft
3724	Aircraft Engine Parts
3761	Guided Missile & Space Vehicles
4173	Terminal and Service Facilities for Motor Vehicle Passenger Transportation
4581	Airports, Flying Fields, and Airport Terminal Services
4593	Refuse System
5093	Recycling
8744	Facilities Support
9711	National Security

(Combs, 1994)

The current AF contains industrial activities that require permits in the categories listed in Table 5. Some of these categories, like air transportation facilities and motor transportation facilities, are applicable to most AF bases. Others, like recycling facilities, are only applicable to a few bases.

Permit Application. "On Nov. 16, 1990, EPA promulgated regulations pertaining to the permit application process for storm water discharges from ... industrial facilities" (Kodukula 1993:54). There were three ways that industrial facilities could apply for a storm water permit. They were: an individual application, covering only that facility; a group application, covering a number of similar facilities; and a Notice on Intent (NOI) to be covered by a general permit, covering all facilities in the descriptive categories requiring a permit. The EPA urged regulated facilities to file for group or general permits, rather that individual permits. However, "...industry's and EPA's thinking evolved to favor general permits as the most efficient and cost-effective route to stormwater discharge permitting" (Bishop 1993: 39) and as a result group permits were never issued.

An individual permit application "require completion of a detailed form providing information specific to a facility, including sampling and characterization data on stormwater discharges from the facility" (Kodukula,

1993:54). The group permit application requires only a faction of the facilities in the group to provide sampling and characterization data on their storm water discharges. Only individual and general types of storm water permits are being issued. (Kodukula, 1993:35; Combs, 1994).

General Permit

Regulation. On Nov. 19, 1993 the "NPDES General Permit for Storm Water Discharges From Industrial Activities" was issued in draft form. This is the general permit to be used for those facilities that filed group applications. It is intended to regulate storm water discharges associated with industrial activities to the waters of the U.S., via either direct discharge or through a municipal separate storm sewer system (EPA, 1993:61146). This permit is only applicable to those states that are not authorized to issue their own NPDES permits. The states that are directly covered by this permit and the states where the federal facilities are covered by this permit are listed in Table 6. The final permit should take effect in late 1994 or early 1995 when the revisions are complete.

Description. The requirements of the "NPDES General Storm Water Permit From Industrial Activities" are given in Table 7. There are no effluent limitations contained in the general storm water permit. Instead facilities are required to develop a Storm Water Pollution Prevention Plan (SWPPP)

Table 6 States Directly Covered by the "NPDES General Permit for Storm Water Discharges From Industrial Facilities	
States Covered by Permit	States Where Federal Facilities are Covered by the Permit
Maine Massachusetts New Hampshire District of Columbia Florida Louisiana New Mexico Oklahoma Texas South Dakota Arizona Alaska Idaho	Vermont Delaware Colorado Washington (Combs, 1994)

that implements all "reasonable" source reduction runoff management practices. The term reasonable is left undefined so that it is up to the individual regulators to determine how it is interpreted and so it may evolve over time. Facilities are also required to monitor certain pollutants unless they can establish a history of sampling results below the bench mark values for those pollutants.

The EPA established the bench mark values for all pollutants observed three or more times within any given industrial sector. These bench mark values along with their sources are listed in Table 8. Since the bench mark values are used as cut off values for requiring sampling and are

Table 7
Requirements of "NPDES General Permit for Storm Water Discharges From Industrial Activities"

- File a Notice of Intent (NOI) to be covered by the permit.
- Special Conditions: prohibition on non storm water discharges.
- Storm Water Pollution Prevention Plan (SWPPP)
  (1) Identify Pollution Prevention team for developing and implementing Plan.
  (2) Identify and describe potential sources of pollution.
  (3) Describe and ensure implementation of practices to reduce pollution.
  (4) Assure compliance with terms and conditions of permit and implement provisions of SWPPP as condition of permit.
- Numeric Effluent Limitations: are industry specific. (There are none for air transportation facilities.)
- Monitoring and Reporting Requirements: are industry specific. (4 times/year during deicing season for air transportation facilities.)

(USEPA, 1993c)

referenced as coming from the "EPA Recommended Ambient Water Quality Criteria", they are assumed to be valid criteria for determining a risk to the environment.

Applied to the AF. The AF applied for a group permit in 1992. The bases that were to be covered by this permit are listed in Appendix C. Since no group permits will be issued, the AF will be covered under the general permit

Table 8
Pollutant Bench Mark Values

Pollutant Name	Bench Mark Value (mg/L or ppm)	Source
biological oxygen demand	9	1
chemical oxygen demand	65	1
total suspended solids	100	1
total kjeldahl nitrogen	105	1
nitrate+nitrite nitrogen	0.68	1
total phosphorus	0.33	1
pH	6.5-9 s.u.	2
1,1,1-trichloroethane	3.1	3
acrylonitrile	7.55	4
aluminum, total	0.75	5
ammonia	19	5
antimony, total	0.088	5
arsenic, total	0.000018	3
barium, total	1.0	6
benzene	5.3	4
beryllium, total	0.13	4
butylbenzyl phthalate	3	3
cadmium, total	0.0018	5
chloride	860	5
copper, total	0.009	5
dimethyl phthalate	313	3
ethylbenzene	32	4
fluoranthrene	3.98	4
iron, total	0.3	3
lead, total	0.0337	5
manganese	0.05	3
mercury, total	0.0024	5
methylene chloride	0.0047	3
naphthalene	2.3	4
nickel, total	0.7884	5
PCB-1016	0.00000044	3
PCB-1221	0.00000044	3
PCB-1242	0.00000044	3
PCB-1248	0.00000044	3
PCB-1254	0.00000044	3
PCB-1260	0.00000044	3
Phenanthrene	0.03	5
phenols, total	10.2	4
pyrene	0.0000028	3
selenium, total	0.02	5
silver, total	0.0009	5
toluene	17.5	4
trichloroethylene	45	4
zinc, total	0.065	5

Sources:
1. NURP
2. "EPA Recommended Ambient Water Quality Criteria." Chronic Aquatic Life Freshwater NA.
3. "EPA Recommended Ambient Water Quality Criteria." Human Health Criteria for Consumption of Water
4. "EPA Recommended Ambient Water Quality Criteria." LOEL Acute Freshwater
5. "EPA Recommended Ambient Water Quality Criteria." Acute Aquatic Life Freshwater
6. "EPA Recommended Ambient Water Quality Criteria." Human Health Criteria for Consumption of

(USEPA, 1993b:61168-61169)

described above. As a result of this change, the AF is encouraging its bases to seek coverage under the state general permits where possible (Combs, 1994). Only those bases (Table 9) in states without NPDES permit authority (Table 7) will be directly covered by the "NPDES General Permit for Storm Water Discharges From Industrial Activities". "However, the remaining states...are expected to issue general stormwater permits modeled on EPA's standard..." for industrial activities (Bishop, 1993:39). The differences between the federal general permit and

Table 9
Air Force Bases Impacted by the Proposed "NPDES General Permit For Storm Water Discharges From Industrial Activities"

Altus AFB	Kelly
Barksdale AFB	Kirtland
Bergstrom AFB	Lackland
Bolling AFB	Laughlin
Brooks AFB	Loring AFB
Cannon AFB	Luke AFB
Carswell AFB	MacDill AFB
Davis-Monthan	Mountain Home AFB
Dyess AFB	Patrick AFB
Eglin AFB	Pease AFB
Eielson AFB	Randolph AFB
Ellsworth AFB	Reese AFB
Elmendorf AFB	Shemya AFB
Goodfellow AFB	Sheppard AFB
Hanscom AFB	Tinker AFB
Holloman AFB	Tyndall AFB
Homestead AFB	Vance AFB
Hurlburt Field	Williams AFB

Some of the bases shown have closed or are closing but this may not relieve the AF of responsibility of the NPS pollution leaving the bases.

specific state general permits changes could be minimal but should be assumed to be at least as stringent than the federal requirements.

Applied to this Study. For this study the "NPDES General Permit For Storm Water Discharges From Industrial Activities" will be used as the minimum current requirements for AF bases. This is due to the fact that the permit is the only storm water permit issued that will widely affect the AF and that it is the newest storm water permit to be issued. While the permit is still in the draft stage, for this study it will be assumed that it is final. It is also assumed that those states not directly affected by this permit will adopt at least the minimum permit requirements.

III. Methodology and Results

This chapter presents the data collected to meet the objectives of this study. It also contains the analysis of that data and the results.

Collecting the Data

An electronic message was sent to the environmental flight chief (or appropriate alternate) at each base in the U.S. This message contained a questionnaire and a request for data (a copy is in Appendix D). Appendix E contains a list of the eighty-one bases contacted. Lt Col Joe Amend (Associate Dean of the School of Civil Engineering and Services) sent a follow-up message to the Base Civil Engineers (BCE), supporting the message. The questionnaire contained direct, easy to answer questions about the base's storm water management program. The message also requested any data resulting from the base's storm water sampling and testing for 1993 and 1994. This was done to obtain a year's worth of the most current storm water data available from the bases. Thirty bases responded to the message via electronic mail, telephone and regular mail. Later, another twenty bases were contacted by telephone.

Data Received

The amount, type and form of the data received varied widely from base to base. Fifty of the eighty-one bases on the contact list responded. Eighteen of these bases had no historical storm water data. Thirty-two bases had historical storm water data and twenty-four of these were able to send that data in time to be included in this study.

Characterizing the Data

The quality of the data received from the bases varied due to the respondents interpretations of the message and the information available. The responding bases sent copies of storm water pollution prevention plans, discharge monitoring reports sent to the state or regional EPA offices, reports sent to the AF major commands (MAJCOMs), test results received from the labs, and hand drawn tables of the testing results. This study combined data from all these sources.

The data used in this study was in response to the six questions listed below.

(1) Does the base have any historical storm water data? Yes or No.

If the answer is yes, then;

(2) How often are the outfalls sampled? Number.

(3) What pollutants are the samples tested for? Pollutant name.

(4) When was the storm water sampled? Date.

(5) What outfall was the sample from? Outfall designation.

(6) What are the concentrations of the pollutants for each outfall and date? Numeric or Character data.

All of the above questions and the types of data they generated, except for number six, are self-explanatory.

The data on the concentrations of pollutants was reported in two ways: numeric or character. The numeric data was actual concentrations of pollutants, for example 16 mg/L of BOD. The character data came in two types. The first was data less than the detection limit of the test. Depending on whether or not the detection limit was specified the data would be recorded as <X units, for example <2 mg/L of BOD, or as ND (None Detected). The second type of character data was NF (No Flow) meaning that the outfall contained no flow at the time it was to be sampled. This was generally due to either a lack of precipitation or freezing temperatures.

Data Analysis

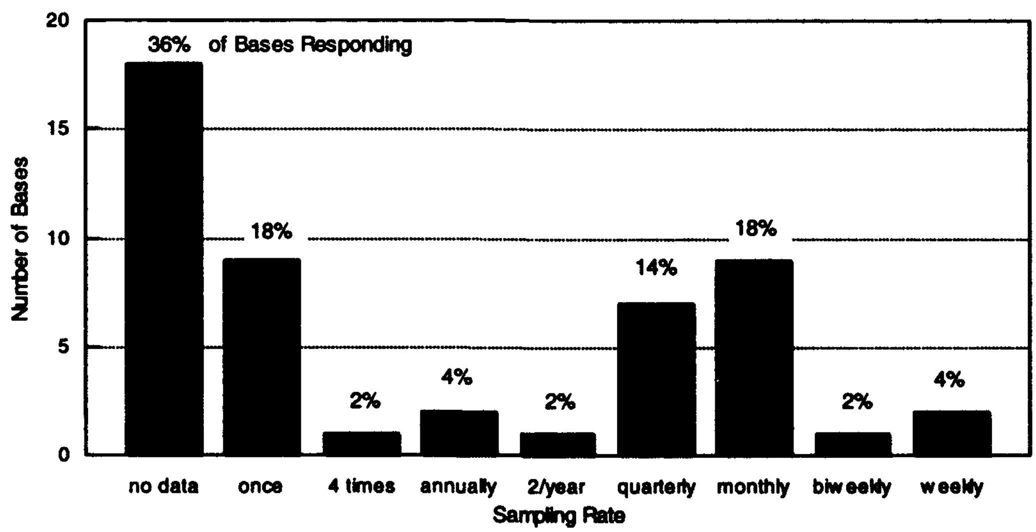
The data collected was used to address objectives of investigative questions one, two, four and five.

Sampling Frequency. The first question asked how often storm water was sampled. This was addressed by placing the data in a spreadsheet to show the sampling programs used at

AF bases (Appendix F). The spreadsheet shows the base designation, its AF MAJCOM, its EPA Region, whether it has historical storm water data, how often sampling is done, and any comments to clarify the sampling situation at the base. This spreadsheet was used to obtain Figure 1 in answer to the first question.

Figure 1 contains a summary of the storm water sampling rates used at the AF bases responding to this study. It is clear from the graph that the largest single sampling category is "no sampling" and that over half the bases surveyed, fifty-four percent, have either never sampled their storm water or have sampled it only once. Bases that have done no sampling may either have a permit for which no sampling is required or have never had to obtain a permit.

Figure 1
Storm Water Sampling Rate of Bases



Bases that had sampled only once generally collected samples as part of their initial application for a NPDES storm water permit, in order to determine what pollutants were present in their storm water effluents. For those bases with a sampling program (at least annual), quarterly and monthly sampling rates were the most common (thirty-two percent of the bases) Regular sampling, either more frequently (weekly or biweekly) or less frequently (annually or twice a year), occur but make up only twelve percent of the total bases responding.

Sampling Frequency Trends. Another question focused on sampling frequency trends across EPA Regions or AF MAJCOMs. There are ten EPA Regions in the U.S., shown in Figure 2, and these regions are designated numerically from one to ten. Bases from all ten EPA regions responded. These bases were from seven AF MAJCOMs: Air Combat Command (ACC), Air Force Materiel Command (AFMC), Air Mobility Command (AMC), Air Education and Training Command (AETC), Pacific Air Force (PACAF), Air Force Reserves (AFRES), and Space Command (SPCOM).

The data in Appendix F was sorted according to EPA Region for the results in Figure 3 and then by AF MAJCOM for the results in Figure 4. The sampling frequencies are listed in three categories: no sampling, some sampling, and regular sampling. The no sampling category is self-explanatory. The some sampling category refers to irregular

Figure 2
U.S. EPA Regions

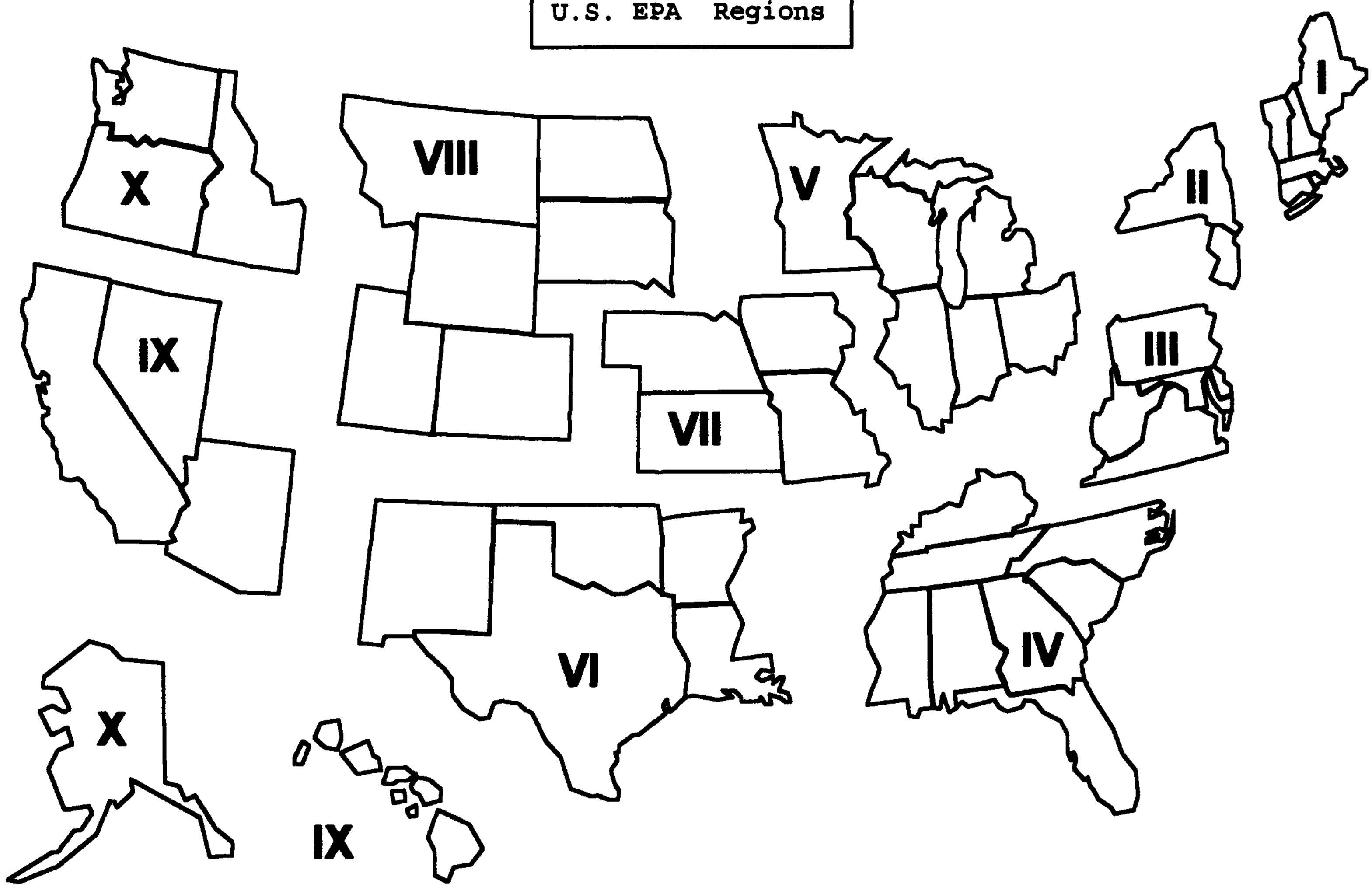


Figure 3
Sampling Rate Sorted by EPA Region

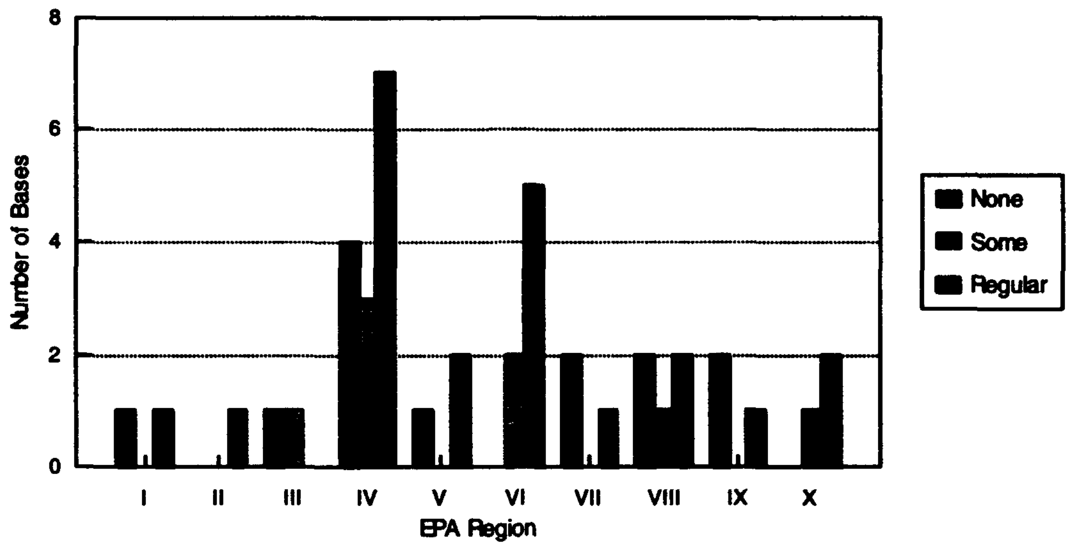
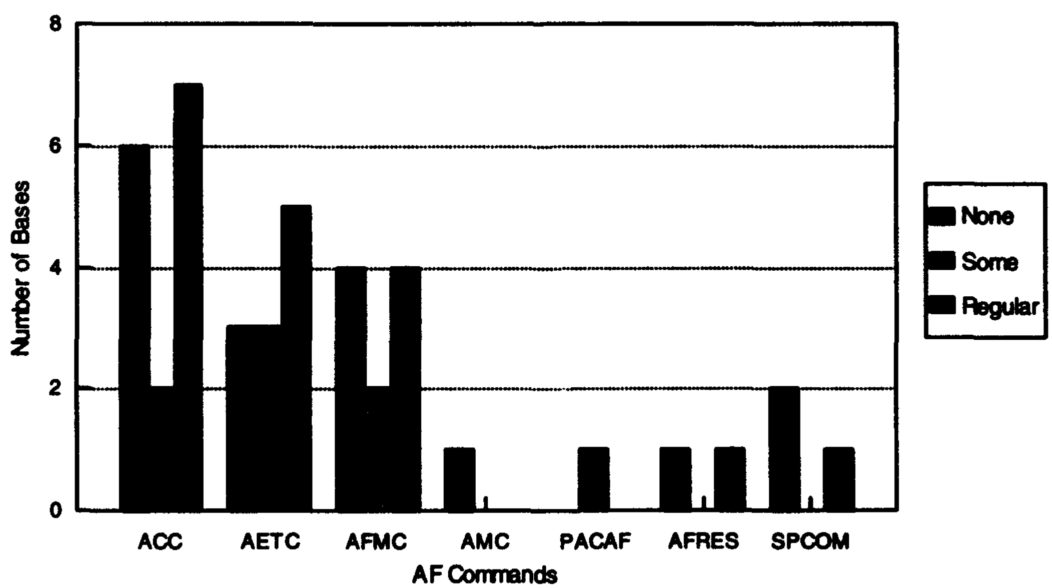


Figure 4
Sampling Rate Sorted by MAJCOM



sampling and regular sampling is sampling that occurs annually, quarterly, monthly, etc.

Figure 3 shows the data to analyze for sampling trends over EPA Region. Only Regions IV, VI and VIII have enough data to justify looking for sampling trends. In Region IV half of the bases responding sample on a regular basis and a quarter of the bases responding have done some sampling. The other quarter of the bases in Region IV have no historical storm water data. In Region VI approximately two-thirds to three-fourths of the bases responding have regular sampling. The rest of the responding bases have done at least some sampling. In Region VIII the responding bases are evenly divided between those sampling regularly (forty percent) and those not sampling at all (forty percent). Only twenty percent of the bases were in the some sampling category. Data from the other regions is too sparse to suggest any trends. Comparing the data in Regions IV and VI suggests that perhaps storm water is of greater concern in Region VI than in Region IV but this could easily be due to the smaller amount of data available for Region VI. Region VIII appears to put less emphasis on their storm water of the three regions.

Figure 4 shows the sampling frequency data by AF MAJCOM. Only ACC, AETC and AFMC have enough data to justify looking for trends in sampling. The ACC bases are almost evenly divided between regular sampling and no sampling with

a few bases falling into the some sampling category. The AETC bases were almost evenly divided among the sampling categories with regular sampling the most common. AFMC data reflects the same trends as ACC. When comparing the data among the three MAJCOMs the only overall trend for the responding bases is that there are either equal or slightly more bases in the regular sampling category.

Testing. The second question was for what pollutants is the storm water effluent tested. Table 10 contains all the pollutants for which the responding bases reported testing their storm water. Table 11 contains all the pollutants for which the bases, engaged in sampling program, had tested for and how many bases had tested for each pollutant. Many bases tested their storm water effluent only once for a very large number (greater than fifteen) of pollutants. In most cases, this was an initial, one time occurrence to determine what pollutants their storm water contained. Table 12 contains those pollutants that were only tested for by bases without a sampling program. It is unlikely that most bases would have problems with that many pollutants or could justify the expense of testing for that many pollutants. Unfortunately, a one time test is a snapshot in time and may not identify seasonal trends in pollutant concentrations.

Table 10 shows all the pollutants for which the responding bases tested their storm water. This list

Table 10
Pollutants Tested For By AF Bases

1,1-Dichloroethane	BTEX
1,1-Dichloroethene	Cadmium
1,1-Dichloroethylene	Carbaryl
1,1,1-Trichloroethane	Carbon Tetrachloride
1,1,1,2-Tetrachloroethane	Chemical Oxygen Demand
1,1,2-Trichloroethane	Chloride
1,1,2,2-Tetrachloroethane	Chlorine, total
1,2-Dichlorobenzene	Chlorobenzene
1,2-Dichloroethane	Chloroethane
1,2-Dichloroethene	Chloroform
1,2-Dichloropropane	Chloromethane
1,3-Dichlorobenzene	Chromium
1,4-Dichlorobenzene	cis-1,1-Dichloroethylene
2-Chloroethylvinyl ether	cis-1,3-Dichloropropene
4,4'-DDD	cis-1,3-Dichloropropylene
4,4'-DDE	Color
4,4'-DDT	Copper, Total
Acetone	Cyanide, Total
Acrylonitrile	Delta-BHC
Aldrin	Diazinon
Alpha-BHC	Dibromochloromethane
Aluminum	Dibromomethane
Ammonia Nitrogen	Dichloromethane
Antimony, Total	Dieldrin
Arsenic, Total	Dissolved Oxygen
Barium, Total	Electrical Conductivity
Benzene	Endosulfan I
Beryllium, Total	Endosulfan II
Beta-BHC	Endosulfan sulfate
Biological Oxygen Demand	Endrin
Boron	Endrin aldehyde
Bromodichloromethane	Ethylbenzene
Bromoethane	Ethylene-Glycol
Bromoform	Fecal Coliform

Table 10 (Cont.)
Pollutants Tested For By AF Bases

Fecal Streptococci	Phenols, Total
Filterable Residue	Phosphorus, Total
Fluoranthrene	Potassium
Gamma-BHC	Propylene Glycol
Hardness	Selenium
Heptachlor	Settable Residue
Heptachlor Epoxide	Sevin
Hydrocarbons	Silver, Total
Iron, Total	Sodium
Lead, Total	Strontium
Lindane	Styrene
Magnesium	Sulfate
Malathion	Surfactants (MBAs)
Manganese	Technical Chlordane
Mercury, Total	Tetrachlorethylene
Methyl Ethyl Ketone	Tetrachloroethene
Methyl Isobutyl Ketone	Thallium
Methylene Chloride	Total Dissolved Solids
Naphthalene	Total Kjeldahl Nitrogen
Nickel, total	Total Organic Carbon
Nitrate	Total Petroleum Hydrocarbons
Nitrate and Nitrite as Nitrogen	Total Suspended Solids
Nitrite	Toluene
Nitrogen	Toxaphen
Oil & Grease	trans-1,1-Dichloroethylene
PCB-1016	trans-1,3-Dichloropropene
PCB-1221	trans-1,3-Dichloropropylene
PCB-1232	Trichloroethene
PCB-1242	Trichloroethylene
PCB-1248	Trichlorofluoromethane
PCB-1254	Turbidity
PCB-1260	Vinyl Chloride
Pentachlorophenol	Xylene
pH	Zinc, Total

Table 11
Pollutants Tested For By AF Bases With Sampling Programs

Pollutants	Number of Bases	Pollutants	Number of Bases
Aldrin	1	Lindane	1
Aluminum	1	Malathion	1
Ammonia Nitrogen	3	Manganese	2
Arsenic	1	Mercury	1
Barium	1	Naphthalene	1
Benzene	2	Nickel, total	2
Biological Oxygen Demand	7	Nitrate	2
Boron	1	Oil & Grease	16
BTEX	1	Pentachlorphenol	1
Cadmium	2	pH	14
Chemical Oxygen Demand	4	Phenols, Total	1
Chloroform	1	Potassium	1
Chloride	1	Propylene Glycol	2
Chlorine	1	Selenium	1
Chromium	4	Settlable Residue	1
Copper, Total	4	Sevin	1
Cyanide, Total	2	Silver, Total	1
Diazinon	1	Sodium	1
Dieldrin	1	Sulfate	1
Dissolved Oxygen	1	Surfactants	2
Electrical Conductivity	1	Total Dissolved Solids	1
Endosulfan I	1	Total Hydrocarbons	1
Endosulfan II	1	Total Kjeldahl Nitrogen	1
Endosulfan Sulfate	1	Total Organic Carbon	1
Endrin	1	Total Phosphorus	2
Ethylbenzene	1	Total Suspended Solids	12
Filterable Residue	1	Toluene	1
Heptachlor	1	Xylene	1
Iron, Total	3	Zinc, Total	2
Lead, Total	3		

Table 12

Pollutants Only Tested For By AF Bases Without Sampling Programs

1,1-Dichloroethane	Endrin aldehyde
1,1-Dichloroethene	Ethylene-Glycol
1,1-Dichloroethylene	Fecal Coliform
1,1,1-Trichloroethane	Fecal Streptococci
1,1,1,2-Tetrachloroethane	Fluoranthrene
1,1,2-Trichloroethane	Gamma-BHC
1,1,2,2-Tetrachloroethane	Hardness
1,2-Dichlorobenzene	Heptachlor Epoxide
1,2-Dichloroethane	Hydrocarbons
1,2-Dichloroethene	Magnesium
1,2-Dichloropropane	Methyl Ethyl Ketone
1,3-Dichlorobenzene	Methyl Isobutyl Ketone
1,4-Dichlorobenzene	Methylene Chloride
2-Chloroethylvinyl ether	Nitrate and Nitrite as Nitrogen
4,4'-DDD	Nitrite
4,4'-DDE	Nitrogen
4,4'-DDT	PCB-1016
Acetone	PCB-1221
Acrylonitrile	PCB-1232
Alpha-BHC	PCB-1242
Antimony, Total	PCB-1248
Beryllium, Total	PCB-1254
Beta-BHC	PCB-1260
Bromodichloromethane	Phosphorus, Total
Bromoethane	Strontium
Bromoform	Styrene
Carbaryl	Technical Chlordane
Carbon Tetrachloride	Tetrachlorethylene
Chlorobenzene	Tetrachloroethene
Chloroethane	Thallium
Chloromethane	Toxaphen
cis-1,1-Dichloroethylene	trans-1,1-Dichloroethylene
cis-1,3-Dichloropropene	trans-1,3-Dichloropropene
cis-1,3-Dichloropropylene	trans-1,3-Dichloropropylene
Color	Trichloroethene
Delta-BHC	Trichloroethylene
Dibromochloromethane	Trichlorofluoromethane
Dibromomethane	Turbidity
Dichloromethane	Vinyl Chloride

contains a total of 136 pollutants listed in alphabetical order. These pollutants range from the conventional, such as BOD and pH, to a wide variety of unconventional pollutants, including pesticides, volatiles, metals, organic and inorganic compounds. Most of the unconventional pollutants come from the EPA's list of toxic pollutants (Appendix A) or their list of other toxic and hazardous pollutants to be identified in storm water (Appendix B).

Table 11 contains the fifty-nine pollutants tested for by bases with storm water sampling programs. There were seventeen responding bases that had sampling programs. The most commonly tested for pollutants are the conventional pollutants of oil and grease (O&G), pH, and total suspended solids (TSS). These pollutants are tested for at most of the responding bases. Since the rest of the pollutants are tested for less frequently, the most frequent is BOD tested for at seven of the bases, it is likely that the others are only tested for where there is a specific state requirement or the pollutant is known to be present.

Exceeding the Bench Mark Values. The last question to be considered was if the pollutant levels in the AF's storm water effluent exceeded the bench mark values (Table 8) from the "Fact Sheet For the Multi-Sector Stormwater General Permit". This question was addressed by analyzing the data using a spreadsheet.

Only data related to the pollutants listed in Table 8, from the "Fact Sheet For the Multi-Sector Stormwater General Permit", were used in the spreadsheet for the following three reasons. The first was that the data was from the most recently published federal storm water permit and therefore should contain the most up to date bench mark values available. Also, a number of AF bases will be covered by this permit, which demonstrates that the data in the permit is applicable to the problem. Last, while limits are available for most if not all of the pollutants that the bases tested for, it is not necessary to compare all the data to limits in order to determine if a problem in AF storm water compliance exists.

The spreadsheet (Appendix G) contained the base designations, the AF MAJCOM, the EPA Region, the outfall designation, sampling date, and the concentration of the pollutants. In order to reduce the tremendous amount of data the pollutant concentrations were recorded on a quarterly basis. If there were pollutant concentrations available more frequently than a quarterly basis then the data was averaged to give a quarterly concentration of that pollutant. If there was character data mixed in with numeric data, it was ignored and only the numeric data was used in the average. This resulted in a tendency for the average to be slightly high in cases were character data was included. At some bases weekly data was available. In

these cases any attempt to work with more than one base at a time was very unwieldy and required multiple spreadsheets. Compressing the data into quarters also allowed seasonal variations to be studied.

The preceding spreadsheet was then used to create two tables that contained:

(1) the pollutant names;

(2) the bench mark values and their units;

(3) the amount of character and numeric data for that pollutant;

(4) the number of bases contributing that data;

(5) the amount of numeric data for that pollutant;

(6) the number of bases contributing that data;

(7) the percentage of the numeric data exceeding the bench mark values (BMV); and

(8) the number of bases contributing that data.

Table 13 shows the results for all the pollutants. Table 14 contains only the results for the pollutants with enough data to justify drawing a conclusion regarding the AF's status for that pollutant. Only those pollutants having a minimum of ten items of numeric data from three or more bases were used. A graph (Figure 5) illustrates the percentage of the data that exceeds the bench mark value for each pollutant. Only those pollutants with enough data for Table 14 were included in Figure 5.

Table 13

Amount of Data Available for Each Pollutant

Pollutants	Bench Mark Values		Total Data Points	Bases Reporting Data	Numeric Data Points	Bases Reporting Data	Percent Data Exceeding BMV	Bases Reporting Data
BOD	9	mg/L	62	11	53	11	40	8
COD	65	mg/L	86	11	70	11	29	6
TSS	100	mg/L	182	20	124	20	12	8
TKN	105	mg/L	74	7	62	7	0	0
N+N Nitrogen	0.68	mg/L	64	6	62	6	68	5
Phosphorus	0.33	mg/L	49	8	33	8	33	5
pH	6.5 - 9.0	s.u.	251	18	224	17	11	6
1,1,1-Trichloroethane	3.1	mg/L	5	2	0	2	---	0
Acrylonitrile	7.55	mg/L	4	0	4	0	100	0
Aluminum	750	µg/L	16	3	16	3	13	2
Ammonia Nitrogen	19	mg/L	30	2	15	2	0	0
Antimony	88	µg/L	8	2	4	1	0	0
Arsenic	0.018	µg/L	19	3	11	2	91	2
Barium	1000	µg/L	1	0	0	0	---	0
Benzene	0.0053	µg/L	12	4	1	2	100	2
Beryllium	130	µg/L	8	2	1	1	0	0
Butylbenzyl Phthalate	3	mg/L	0	0	0	0	---	0
Cadmium	1.8	µg/L	26	5	17	4	35	3
Chloride	0.009	mg/L	12	1	10	1	90	1
Copper	9	µg/L	37	7	26	7	96	6
Dimethyl Phthalate	313	mg/L	0	0	0	0	---	0
Ethylbenzene	32000	µg/L	13	4	2	2	0	0

Table 13 (Cont.)
Amount of Data Available for Each Pollutant

Pollutants	Bench Mark Values		Total Data Points	Bases Reporting Data	Numeric Data Points	Bases Reporting Data	Percent Data Exceeding BMV	Bases Reporting Data
Fluoranthrene	3.98	mg/L	0	0	0	0	---	0
Iron	300	µg/L	22	4	22	4	50	3
Lead	33.7	µg/L	33	6	23	6	26	3
Manganese	50	µg/L	12	3	10	3	90	3
Mercury	2.4	µg/L	19	3	10	1	0	0
Methylene Chloride	0.0047	mg/L	1	1	1	1	100	1
Naphthalene	2.3	mg/L	12	1	0	0	---	0
Nickel	788.4	µg/L	16	5	7	2	0	0
PCB-1016	0.00044	µg/L	2	1	0	0	---	0
PCB-1221	0.00044	µg/L	2	1	0	0	---	0
PCB-1232	0.00044	µg/L	2	1	0	0	---	0
PCB-1242	0.00044	µg/L	2	1	0	0	---	0
PCB-1248	0.00044	µg/L	2	1	0	0	---	0
PCB-1254	0.00044	µg/L	2	1	0	0	---	0
PCB-1260	0.00044	µg/L	2	1	0	0	---	0
Phenanthrene	0.03	mg/L	0	0	0	0	---	0
Phenols	10.2	µg/L	20	4	15	4	40	3
Pyrene	0.0028	µg/L	0	0	0	0	---	0
Selenium	20	µg/L	18	3	12	2	17	1
Silver	0.9	µg/L	22	4	11	2	91	2
Toluene	17500	µg/L	12	3	2	2	0	0
Trichloroethylene	45	mg/L	4	1	0	0	---	0
Zinc	65	µg/L	33	7	26	6	50	5

Table 14
Amount of Data Available for Pollutants Meeting Minimum Data Requirements

Pollutants	Bench Mark Values	Total Data Points	Bases Reporting Data	Numeric Data Points	Bases Reporting Data	Percent Data Exceeding BMV	Bases Reporting Data
BOD	9 mg/L	62	11	53	11	40	8
COD	65 mg/L	86	11	70	11	29	6
TSS	100 mg/L	182	20	124	20	12	8
TKN	105 mg/L	74	7	62	7	0	0
N+N Nitrogen	0.68 mg/L	64	6	62	6	68	5
Phosphorus	0.33 mg/L	49	8	33	8	33	5
pH	6.5 - 9.0 s.u.	251	18	224	17	11	6
Aluminum	750 µg/L	16	3	16	3	13	2
Cadmium	1.8 µg/L	26	5	17	4	35	3
Copper	9 µg/L	37	7	26	7	96	6
Iron	300 µg/L	22	4	22	4	50	3
Lead	33.7 µg/L	33	6	23	6	26	3
Manganese	50 µg/L	12	3	10	3	90	3
Phenols	10.2 µg/L	20	4	15	4	40	3
Zinc	65 µg/L	33	7	26	6	50	5

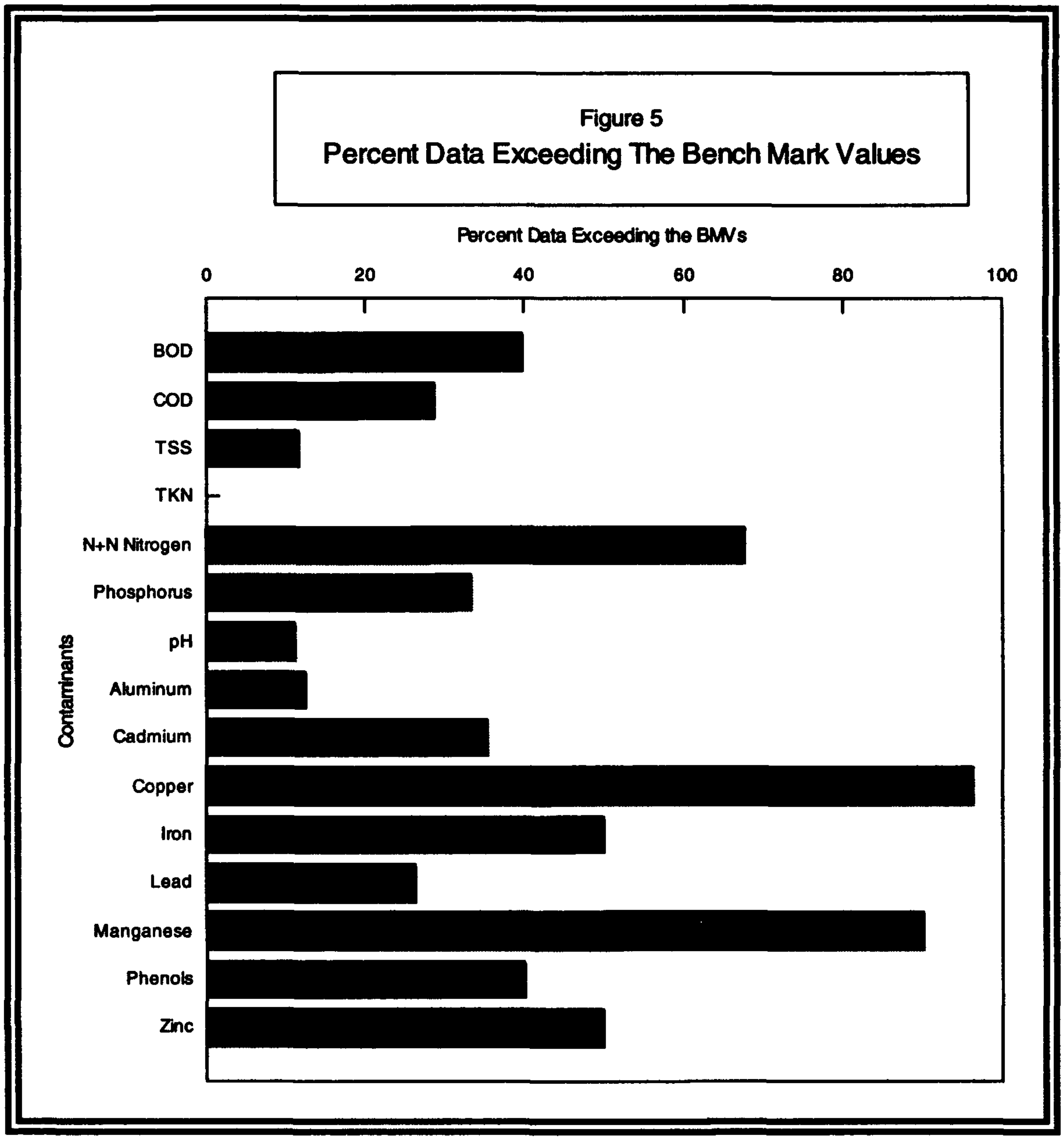


Table 13 contains the amount of AF data for each of the pollutants. It is clear that the quality and quantity of data for some of the forty-five pollutants is inadequate to evaluate the AF. There is no data for five of the

pollutants (butylbenzyl phthalate, dimethyl phthalate, fluoranthrene, phenanthrene, and pyrene). There is no numeric data for eleven of the pollutants (1,1,1-Trichloroethane, Barium, Naphthalene, Trichloroethylene, or any of the PCBs). Fourteen other pollutants did not have sufficient data to draw conclusions. The fifteen pollutants which met the minimum data requirements are listed in Table 14. Figure 5 shows the percentages of selected pollutants that exceed the bench mark values.

Examination of the data allows a number of observations (Table 15). First, of the fifteen pollutants listed, only Total Kjeldahl Nitrogen (TKN) presents no problems with meeting the bench mark value. At the other end of the scale, the AF data is almost uniform for copper with ninety-six percent of the data above the bench mark value. This could indicate that the bench mark value for copper may be set lower than the background concentrations. For pH, only two bases display a widespread continuous problem (pH is lower than acceptable). The other bases, only had passing problems with pH data exceeding the bench mark values. It is possible that the problem with lead, phosphorus, and total suspended solids are also localized, to one, two and three bases, respectively. But, existing data is inadequate to confirm this conclusion. These are the only pollutants for which the data displays a definite trend toward meeting or exceeding the bench mark values. The problems for the

Table 15 Comments on Data Exceeding the Bench Mark Values		
Pollutants	Comment on Problem	Base Responsible
Aluminum	No trends	
BOD	Individual bases tend toward either meeting the BMVs completely or exceeding them completely	
Cadmium	No trends	
COD	Individual bases tend toward either meeting the BMVs completely or exceeding them completely	
Copper	Uniformly exceeds BMVs	
Iron	No trends	
Lead	Mainly caused by one base	GRNY
Manganese	No trends	
N+N Nitrogen	There is one base that meets the BMVs (KEMI)	
pH	Mainly caused by two bases	GRND, PAFL
Phenols	No trends	
Phosphorus	Mainly caused by one base and partially due to MAAL	ALOK
TKN	No problem	
TSS	Mainly caused by three bases	ALOK, ANMD, KEMI
Zinc	No trends	

other pollutants range from as low as thirteen percent of the bases reporting aluminum up to ninety percent for manganese. For BOD and COD, the individual AF bases tended either towards completely meeting the bench mark values or

completely exceeding them. For the rest of the pollutants, the AF's status varied widely from base to base.

Trends In Data Exceeding the Bench Mark Values. Another question focused on evaluating trends at the AF bases across EPA Regions or AF MAJCOMs. The data from the bases was also examined in order to evaluate seasonal changes in compliance. The data was used to create three tables, one for each area of concern. These tables contained only those pollutants which met minimum data requirements. Table 16 contains seasonal data and, for each quarter shows the number of data points and the percentage of data exceeding the bench mark values. If there were less than five data points available for a pollutant during a particular season, the data was assumed to be inadequate for making any assumptions and was not included in the table. A graph (Figure 6) illustrating selected data was also included.

The other two tables are similar in that they also show the number of data points and the percentage of data exceeding the bench mark values. For the EPA Regions (Table 17), data was provided if three or more bases were present in the region. It was assumed that at least three bases were needed to assess storm water status. For the AF MAJCOMs (Table 18) data was provided for MAJCOMs with data from three or more bases. These tables, like the table containing the seasonal data, only contained the data and

Table 16
Seasonal Data

	QTR 1		QTR 2		QTR 3		Qtr 4	
Pollutant	Data Points	Percent Data Exc. BMVs.	Data Points	Percent Data Exc. BMVs.	Data Points	Percent Data Exc. BMVs.	Data Points	Percent Data Exc. BMVs.
BOD	13	54	12	33	19	42	9	22
COD	8	0	21	43	23	13	18	44
TSS	36	3	38	16	49	20	33	3
TKN	7	0	18	0	24	0	13	0
N+N Nitrogen	8	63	16	75	21	52	17	82
Phosphorus	7	14	11	55	10	30	5	20
pH	51	4	57	23	56	9	60	8
Aluminum					8	25		
Cadmium			6	50			7	43
Copper			8	100	5	80	10	100
Iron					10	60		
Lead			7	29	8	13	6	33
Manganese					5	100		
Phenols							8	63
Zinc			6	33	8	50	10	60

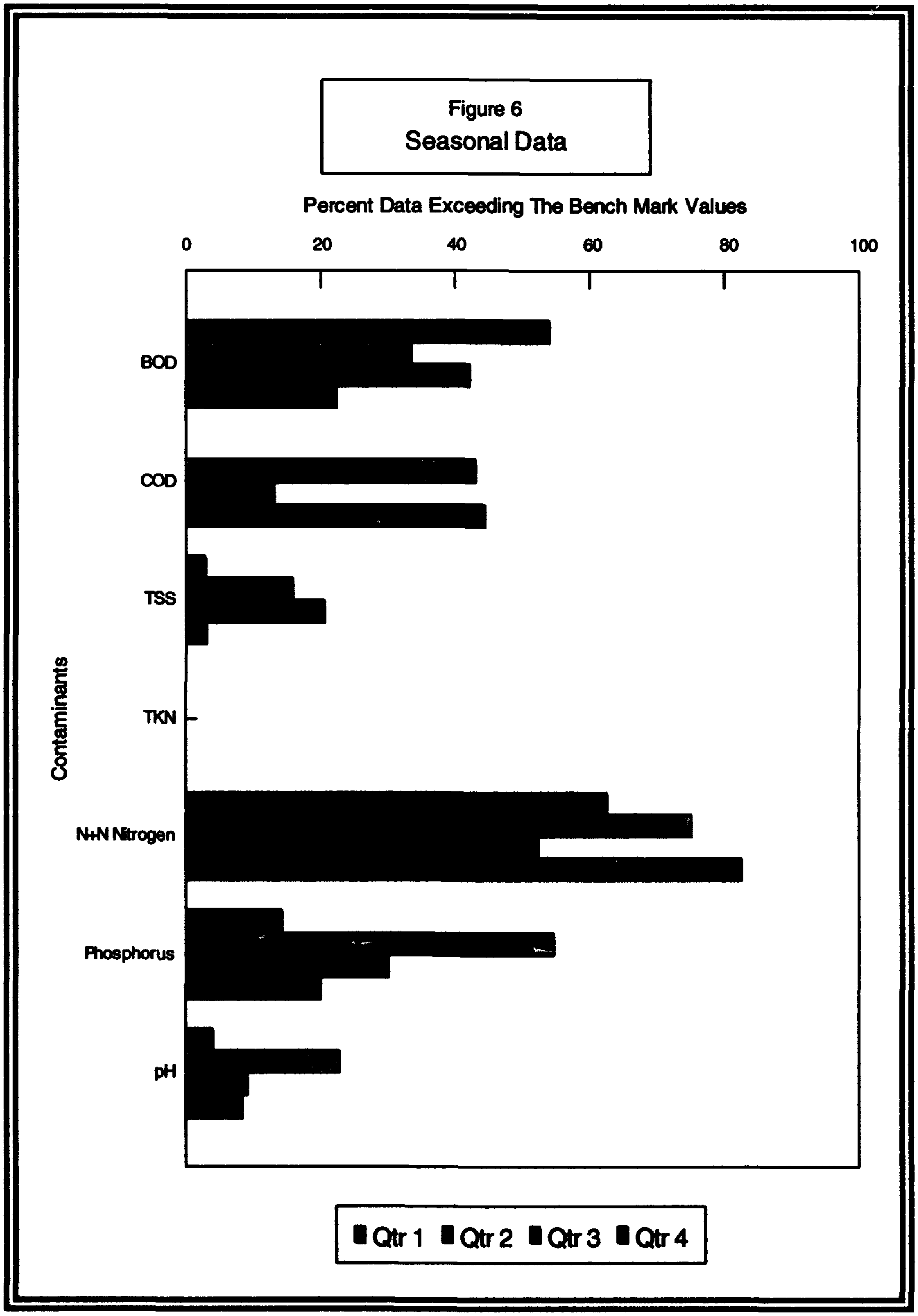


Figure 6
Seasonal Data
Percent Data Exceeding The Bench Mark Values
0
20
40
60
80
100
BOD
COD
TSS
TKN
N+N Nitrogen
Phosphorus
pH
Contaminants
Qtr 1
Qtr 2
Qtr 3
Qtr 4

percent data exceeding the bench mark value for a pollutant if there was a minimum of five data items.

The seasonal data is shown in Table 16 and Figure 6. Only BOD, COD, TSS, TKN, N+N Nitrogen, phosphorus, and pH have adequate data to evaluate the seasonal variations all year. These are the pollutants contained in the graph. The seasonal variations in the data for these pollutants are described below. The data for COD, TSS, phosphorus, and pH show the clearest seasonal variations in exceeding the bench mark values. COD is a much larger problem in the spring and fall than in the summer, and appears to disappear completely during the winter. TSS is a larger problem in the spring and summer and is a smaller problem in the fall and winter. The last two, phosphorus and pH, both have the same patterns in the compliance data. The problems are smallest in the winter, then more than triple in the spring, and then settle back down in the summer and fall. The other pollutants appear to also have seasonal variations in compliance, but these variations are less pronounced.

The data sorted by EPA Region is contained in Table 17. This data is illustrated in Figures 7, 8, 9, and 10, where the percent data in exceeding the bench mark values for each region is compared with that of the AF. All of these values are based only on the data from the bases responding for this study. There are some pollutants for which a particular EPA Region averages better compliance than the AF

Table 17

Percent Data Exceeding the Bench Mark Values By EPA Region

EPA Regions	IV		VI		VII		X		AF	
Contaminants	Data Points	Percent Data	Data Points	Percent Data	Data Points	Percent Data	Data Points	Percent Data	Data Points	Percent Data
BOD	11	9	7	57	9	44	9	56	53	40
COD			28	36	27	11			70	29
TSS	90	8	13	31			10	10	156	12
TKN	6	0			25	0	5	0	62	0
N+N Nitrogen	6	0			26	81	8	63	62	68
Phosphorus	12	50			14	7			33	33
pH	62	19	40	3	39	21			224	11
Aluminum			12	0					20	20
Cadmium					10	0			17	35
Copper					10	90			26	96
Iron							10	70	22	50
Lead					10	0			23	26
Manganese							7	86	10	90
Phenols					9	0			15	40
Zinc					10	0			26	50

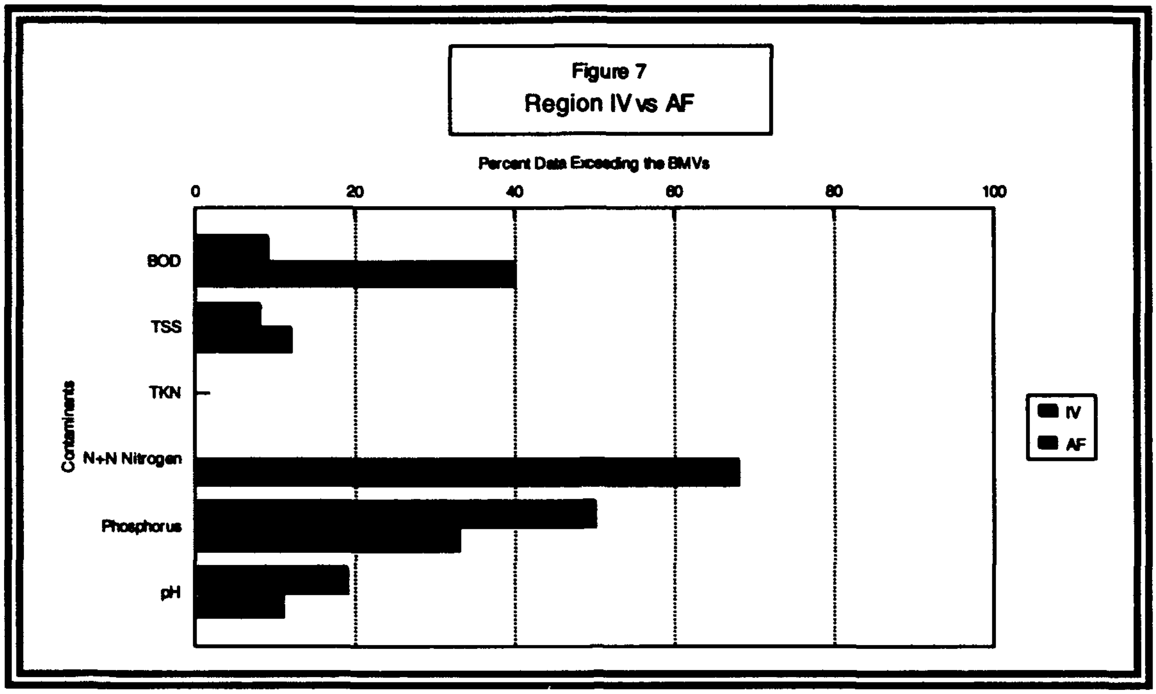


Figure 7
Region IV vs AF
Percent Data Exceeding the BMVs
0
20
40
60
80
100
BOD
TSS
TKN
N+N Nitrogen
Phosphorus
pH
Contaminants
IV
AF

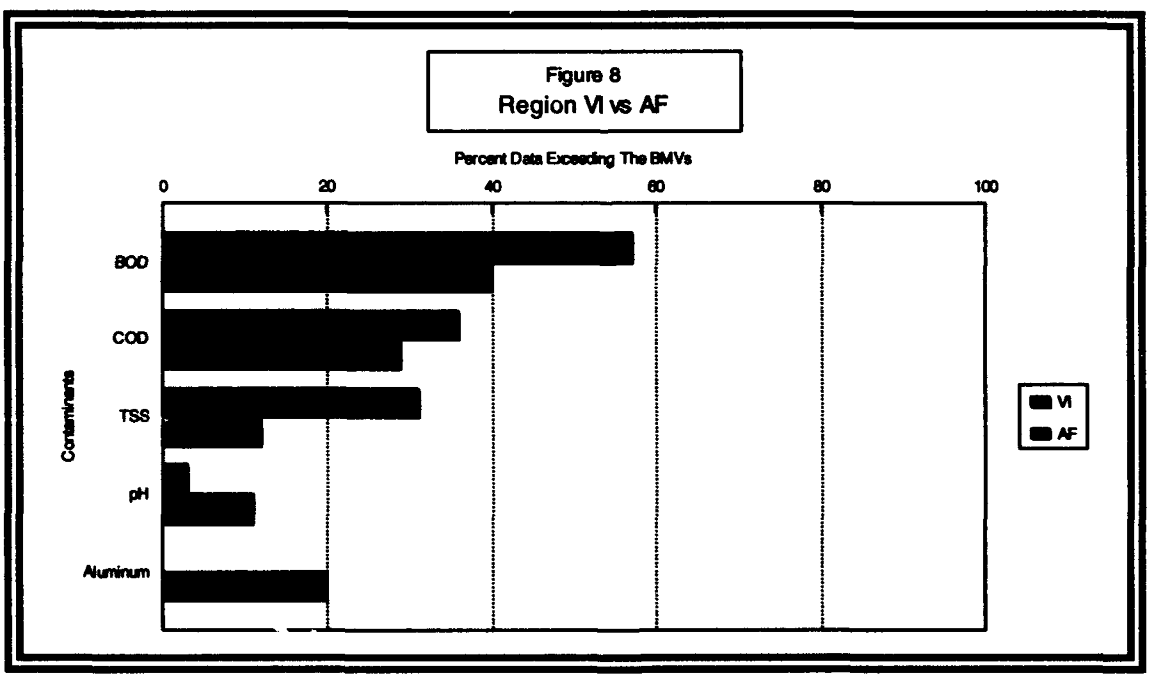
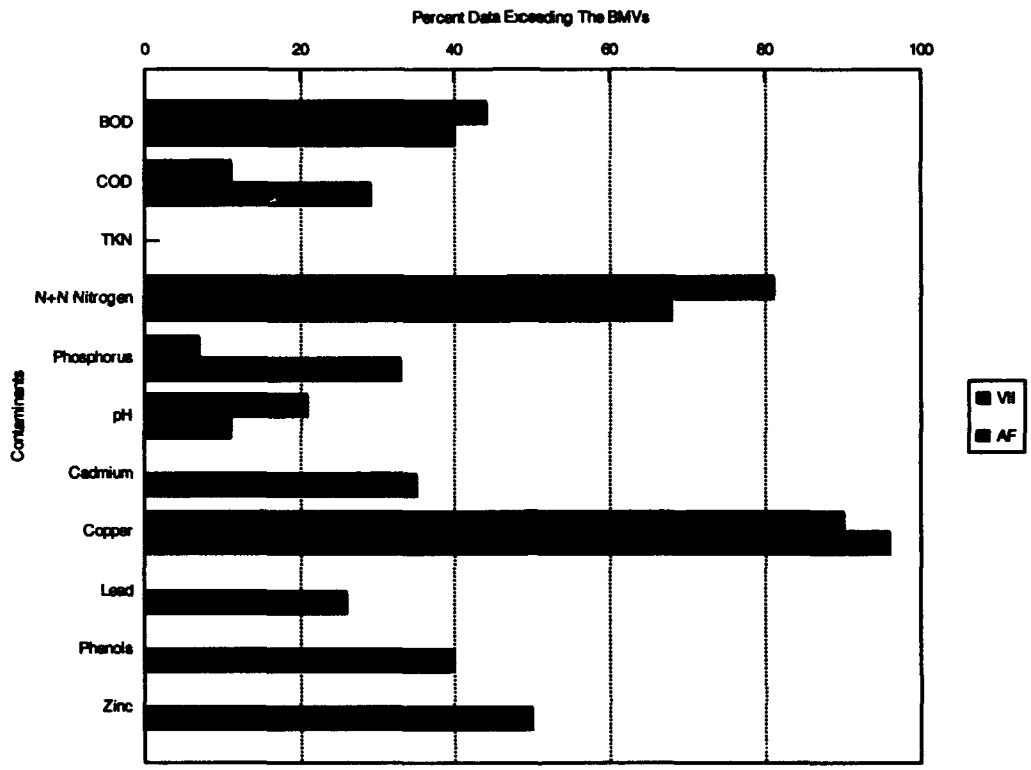


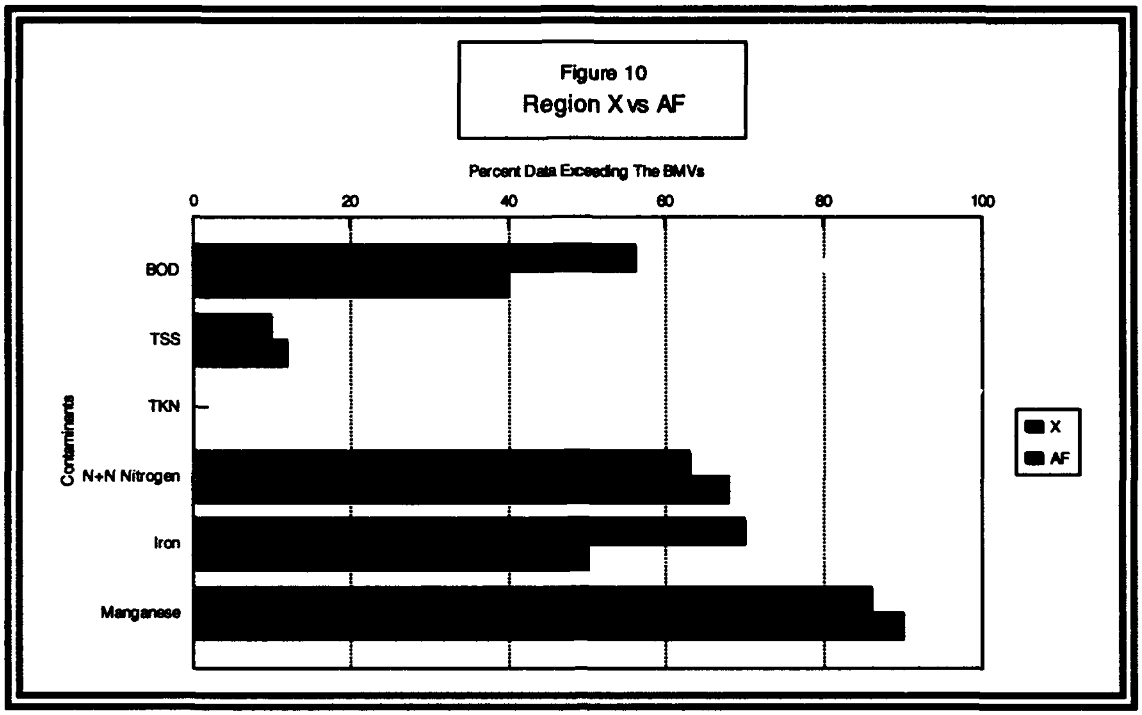
Figure 8
Region VI vs AF
Percent Data Exceeding The BMVs
0
20
40
60
80
100
BOD
COD
TSS
pH
Aluminum
Contaminants
VI
AF

Figure 9
Region VII vs AF



and some pollutants for which that EPA Region averages worse compliance. None of the regions average better compliance for all the pollutants or worse compliance for all the pollutants. This is the only conclusion that can be made regarding EPA Regions due to lack of data.

The data that is sorted by AF MAJCOM is contained in Table 18. This data is illustrated in Figure 11, 12, 13, and 14, where the percent data exceeding the bench mark values for each MAJCOM is compared with that of the AF. The



AF MAJCOMs are similar to the EPA Regions in that no MAJCOM is completely better than the AF or completely worse for all the pollutants. However, ACC meets the bench mark values for TSS and TKN. It is also in better shape than the AF as a whole in BOD and pH. Only for N+N Nitrogen is ACC in worse shape that the AF and there the difference is only two percent. Out of the four AF MAJCOMs with adequate data, ACC's is the MAJCOM that is leading the AF in meeting the bench mark values. This is the only conclusion that can be drawn regarding the AF MAJCOMs due to the lack of data.

Figure 18

Percent Data Exceeding The Bench Mark Values By MAJCOM

Major Commands	ACC		AETC		AFMC		AMC		AF	
Contaminants	Data Points	Percent Data Exc. BMVs	Data Points	Percent Data Exc. BMVs	Data Points	Percent Data Exc. BMVs	Data Points	Percent Data Exc. BMVs	Data Points	Percent Data Exc. BMVs
BOD	22	36	14	29	4	25	8	38	53	40
COD			10	60	15	53	37	16	70	29
TSS	53	0	50	22	24	13	8	38	156	12
TKN	20	0	10	0			27	0	62	0
N+N Nitrogen	20	70	10	40			32	75	62	68
Phosphorus			16	56			12	17	33	33
pH	100	4	16	0	47	2	38	24	224	11
Aluminum					12	0			20	20
Cadmium					5	80	12	17	17	35
Copper					10	100	13	92	26	96
Iron					8	50			22	50
Lead							15	7	23	26
Manganese									10	90
Phenols					5	100	10	10	15	40
Zinc					6	100	14	29	26	50

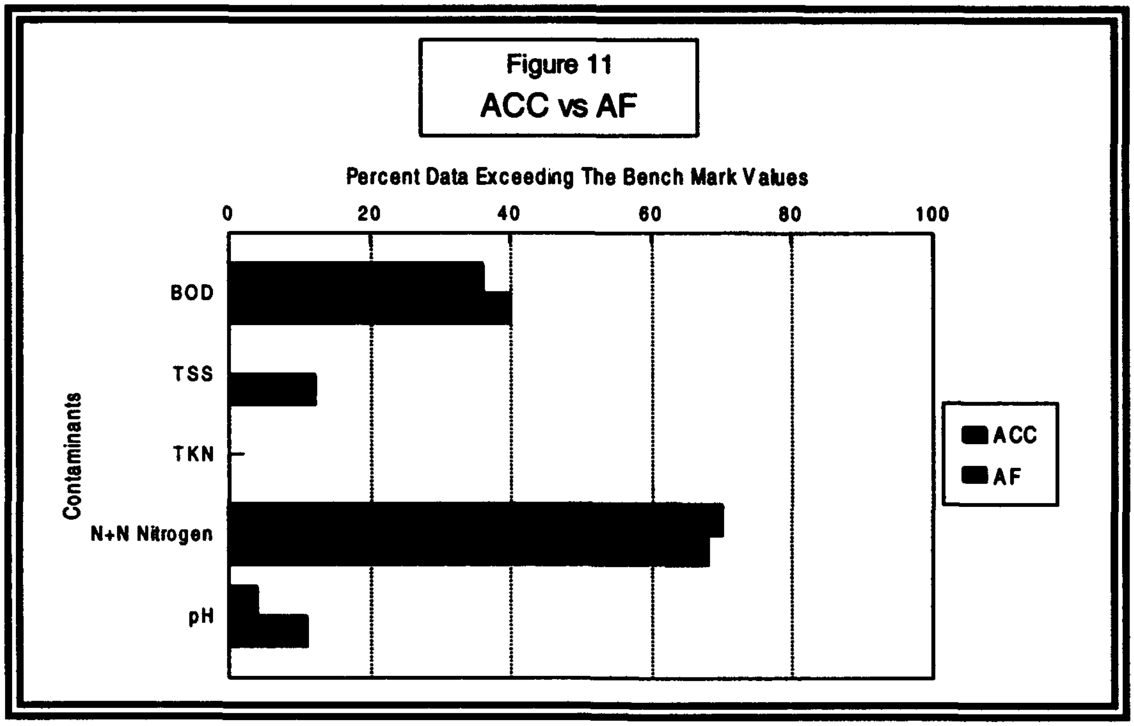


Figure 11
ACC vs AF
Percent Data Exceeding The Bench Mark Values
0
20
40
60
80
100
BOD
TSS
TKN
N+N Nitrogen
pH
Contaminants
ACC
AF

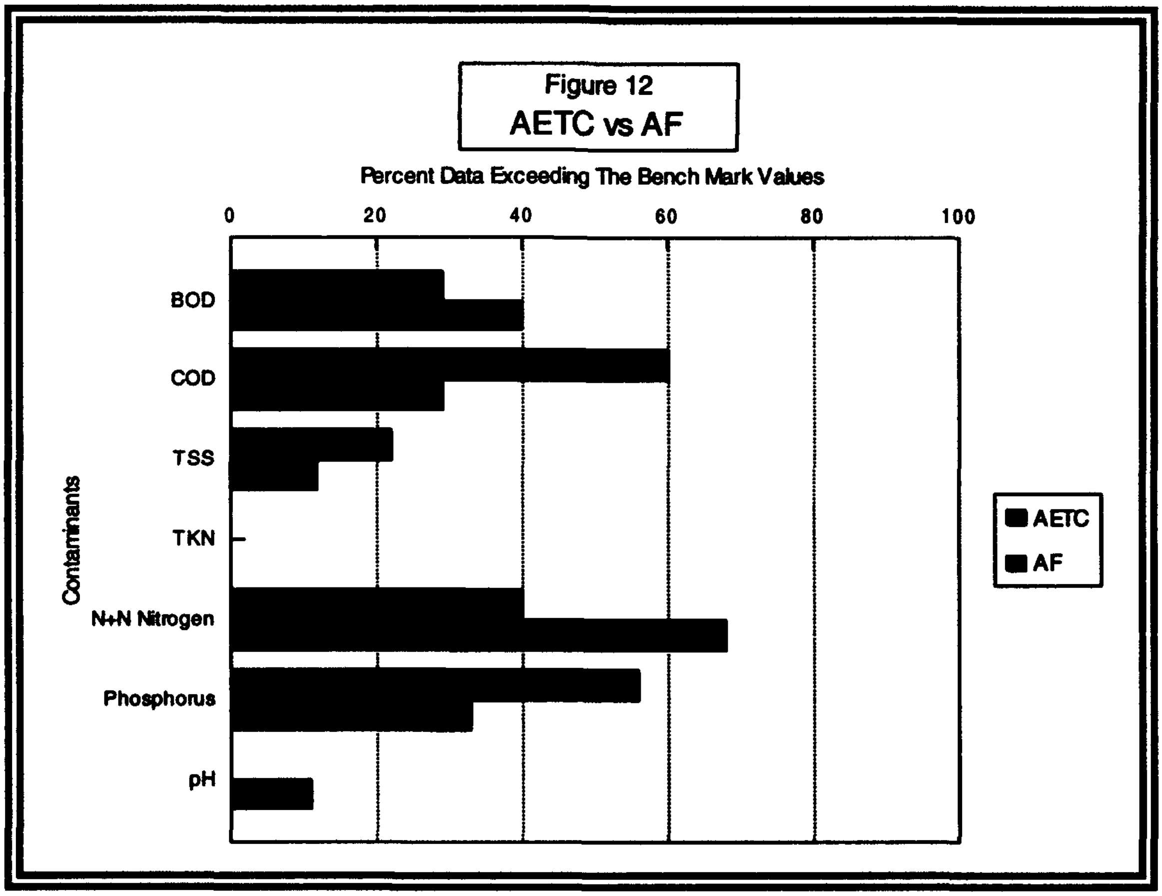


Figure 12
AETC vs AF
Percent Data Exceeding The Bench Mark Values
0
20
40
60
80
100
BOD
COD
TSS
TKN
N+N Nitrogen
Phosphorus
pH
Contaminants
AETC
AF

Figure 13
AFMC vs AF

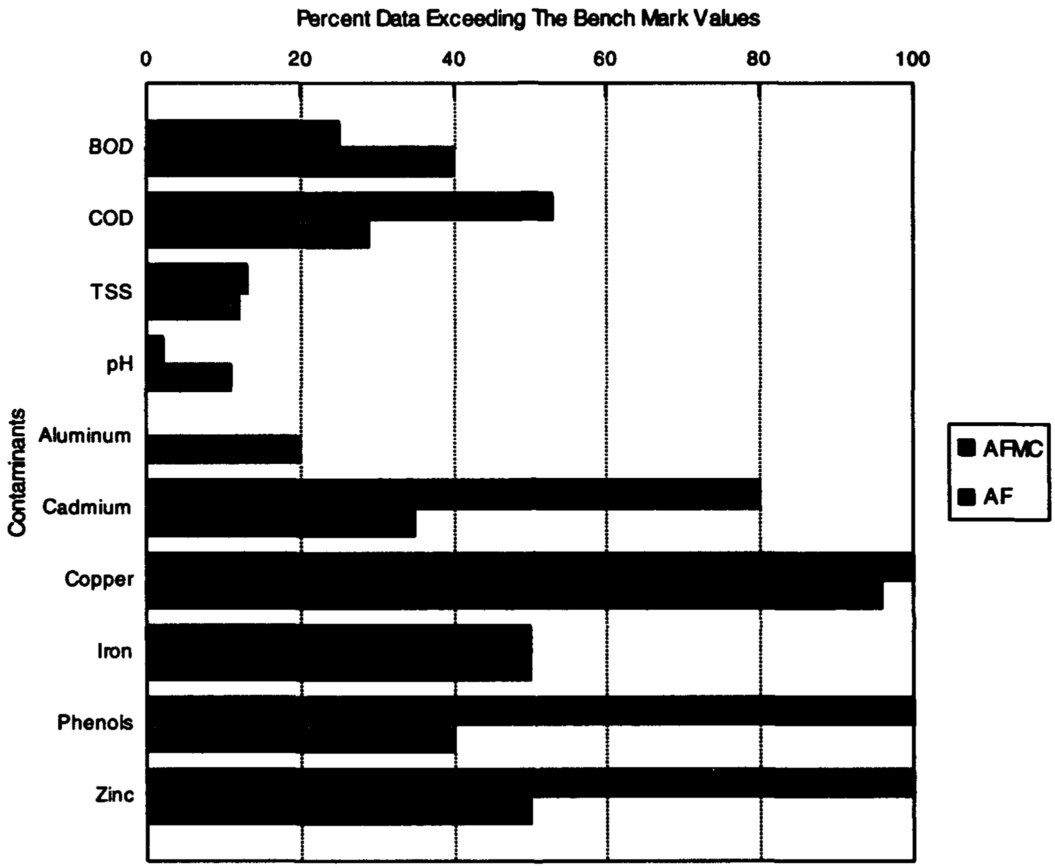
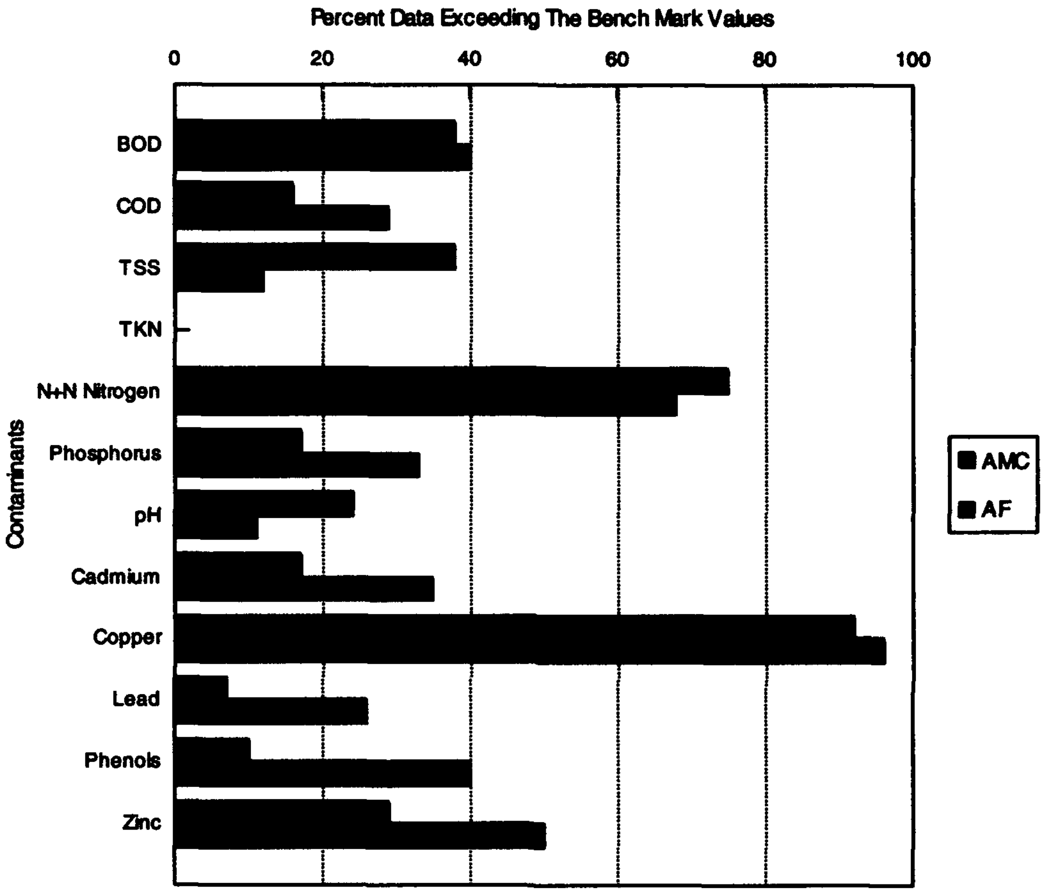


Figure 14
AMC vs AF



IV. Conclusions

This study examined and evaluated current storm water sampling and testing practices on AF bases. It determined if storm water effluent from the bases exceeded the bench mark values from the EPA proposed general permit, using current storm water pollutant concentrations. This chapter contains the conclusions drawn from the study, recommendations for the AF, and recommendations for future research.

Sampling Frequency

Figure 2 shows that a wide range of sampling rates are employed by the AF bases surveyed. If these bases are representative of the whole AF, it can be concluded that the AF does not have a consistent policy on how often to sample storm water discharges. The new general NPDES permit, which eventually will apply to most of the AF, will require sampling four times a year during the winter months for bases with a flying mission. The only bases now sampling that often are those bases sampling on a monthly basis or more often. Only twenty-four percent of the bases responding sample that often. Most of the bases surveyed, fifty-six percent, have no regular sampling programs. AF bases should be meeting the minimum permit sampling requirements of sampling four times during the winter and

those bases exceeding the bench mark values should be sampling at least quarterly.

Testing

The storm water effluent sampled is tested for a number of pollutants. However, there is no standard list of pollutants that are tested for across the AF bases. Since the reasoning behind choosing the particular pollutants tested for by bases is not defined, there is no way to determine if bases are testing for too many or too few pollutants.

One potential problem was identified from the data. Most bases engage in sampling prior to being issued a permit to determine what pollutants are present. Since these bases generally sample only once, they may be missing pollutant problems with seasonal variations. Initial sampling to determine the presence of pollutants should be conducted at least on a quarterly basis over the course of a year. In addition, the AF should develop a methodology for determining what pollutants should be analyzed for and when samplings should be conducted.

Regulations

In general, all AF bases should be prepared to meet the requirements for the "NPDES General Permit for Storm Water From Industrial Activities" as listed in Table 7. As

described in Chapter II of this study, these requirements will be the minimum that most AF bases will need to meet. Depending on the circumstances of a particular base or the state in which the base is located, the discharge limits may be more stringent and the sampling requirements more frequent.

In addition to the above, the U.S. is currently experiencing a trend toward stricter environmental requirements (Combs, Dodson, 1994). As long as this trend continues the AF must be prepared to constantly increase its efforts to avoid, reduce, and remove contaminants in storm water. Ultimately the emphasis should be in removing the pollutants from the base environment, prior to being transported by storm water.

Bench Mark Values

Keeping pollutant concentrations below the bench mark values provided by the EPA should be a goal of the AF. State and federal regulators are under increasing pressure to identify and fine polluters. As long as pollutant concentrations are above the EPA recommended ambient water quality levels, there will always be the potential for the AF to be subject to civil penalties and to become involved in damaging (to public relations) civil suits involving individuals exposed to those contaminants downstream from a base. Since the bench mark values are included in the

general permit, they are a good standard with which to begin working. However, the AF should be preparing for the possibility of more stringent standards in the future.

The only contaminant for which the AF is meeting the bench mark values is Total Kjeldahl Nitrogen (TKN). There are four pollutants (aluminum, pH, phosphorus, lead) for which the AF exceeds the bench mark values due to problems with one or two of the bases surveyed. There are eleven other pollutants for which the AF exceeds the bench mark values at rates ranging from eleven percent to ninety percent of the data.

Figure 6 shows that seasonal changes exist for all pollutant concentrations and in the case of some pollutants, seasonal variations can be significant. This fact should be considered in determining the frequency and quarter to sample outfalls, especially if sampling is required less than quarterly. Otherwise a problem might go undetected.

Figures 7, 8, 9, and 10 show, that of the EPA regions with sufficient data to draw conclusions, the percent data meeting the bench mark values varies from region to region and from pollutant to pollutant. None of the regions have an overall better or worse average than the AF in meeting the bench mark values.

Figures 11, 12, 13, and 14 show, that for the AF regions with sufficient data to draw conclusions, the percentage data meeting the bench mark values varies from

MAJCOM to MAJCOM and from pollutant to pollutant. Only ACC is closer to meeting the bench mark values than the whole AF for all the pollutants but one.

Recommendations

The following are recommendations for the AF:

(1) The AF should establish mandatory storm water sampling requirements for all bases to ensure sufficient data is available to detect and characterize any pollutant sources.

(2) For those bases with contaminant concentrations exceeding the standards or having the potential to exceed the standards, a more rigorous sampling plan should be implemented, and mitigating measures implemented and remedial actions taken to identify and eliminate source.

(3) Establish base data in MAJCOM data banks to track and assist in mitigating and remedial actions and to ensure full compliance with existing NPDES permits or proposed standards. (This data could be used for base's potential for mission changes.)

The reason for these recommendations is clearly expressed by the following statement.

> Taking an active role in the process, including working with regulatory agencies, is often the least costly approach and may help you retain more control than you might otherwise be of.ered if storm water treatment and other redemption measures are required. Site cleanups that are unilaterally ordered and/or executed by regulatory agencies usually result in little or no control over the nature and extent of the

investigation, the selected solutions, or the schedule of implementation. (Miller, 1991:94)

Recommendations for Future Research

This study identified a problem with the AF's storm water control. However, if the AF would sponsor data collection in advance of further study, more in depth analyses could be performed. With data from all of the bases, the extent of the AF's storm water problem could be determined. In addition, it would be possible to go beyond simple data analysis and do a more extensive statistical analysis of the data.

Another area where further research could be conducted is in evaluating the standards that the AF is trying to meet. In the case of the bench mark values used in this study, at least some of these values for pollutants are so low that they might be below background levels and impossible to meet. Realistic bench mark values are central to a credible NPS control program. An evaluation of the standards could be used to determine when mitigative and control measures could improve the situation.

Appendix A: Toxic Pollutants

Volatiles		
Acrolein	Dichlorobromomethane	1,1,2,2-Tetrachloroethane
Acrylonitrile	1,1-Dichloroethane	Tetrachloroethylene
Benzene	1,2-Dichloroethane	Toluene
Bromoform	1,1-Dichloroethylene	1,2-Trans-dichloroethylene
Carbon tetrachloride	1,2-Dichloropropane	1,1,1-Trichloroethane
Chlorobenzene	1,3-Dichloropropylene	1,1,2-Trichloroethane
Chlorodibromomethane	Ethylbenzene	Trichloroethylene
Chloroethane	Methyl bromide	Vinyl chloride
2-Chloroethylvinyl ether	Methyl chloride	
Chloroform	Methylene chloride	

Pesticides		
Aldrin	Delta-BHC	PCB-1221
Alpha-BHC	Dieldrin	PCB-1232
Alpha-endosulfan	Endosulfan sulfate	PCB-1242
Beta-BHC	Endrin	PCB-1248
Beta-endosulfan	Endrin aldehyde	PCB-1254
Chlordane	Gamma-BHC	PCB-1260
4,4'-DDD	Heptachlor	Toxaphene
4,4'-DDE	Heptachlor epoxide	
4,4'-DDT	PCB-1016	

Acid Compounds		
2-Chlorophenol	2,4-Dinitrophenol	Pentachlorophenol
2,4-Dichlorophenol	2-Nitrophenol	Phenol
2,4-Dimethylphenol	4-Nitrophenol	2,4,6-Trichlorophenol
4,6-Dinitro-o-cresol	p-Chloro-m-cresol	

Base/Neutral		
Acenaphthene	4-Chlorophenyl phenyl ether	Hexachlorobenzene
Acenaphthylene	Crysene	Hexachlorobutadiene
Anthracene	Dibenzo(a,h)anthracene	Hexachlorocyclopentadiene
Benzidine	1,2-Dichlorobenzene	Hexachloroethane
Benzo(a)anthracene	1,3-Dichlorobenzene	Indeno(1,2,3-cd)pyrene
Benzo(a)pyrene	1,4-Dichlorobenzene	Isophorone
3,4-Benzofluoranthrene	3,3'-Dichlorobenzidine	Napthalene
Benzo(ghi)perylene	Diethyl phthalate	Nitrobenzene
Benzo(k)fluoranthrene	Dimethyl phthalate	N-Nitrosodimethylamine
Bis(2-chloroethoxy)methane	Di-n-butyl phthalate	N-Nitrosodi-n-propylamine
Bis(2-chloroethyl)ether	2,4-Dinitrotoluene	N-Nitrosodiphenylamine
Bis(2-chloroisopropyl)ether	2,6-Dinitrotoluene	Phenanthrene
Bis(2-ethylhexyl)phthalate	Di-n-octyl phthalate	Pyrene
4-Bromophenyl phenyl ether	1,2-Diphenylhydrazine	1,2,4-Trichlorobenzene
Butylbenzyl phthalate	Fluroranthene	
2-Chloronaphthalene	Fluorene	

Metals, Cyanide, Phenols		
Antimony	Copper	Phenols
Arsenic	Cyanide	Selenium
Beryllium	Lead	Silver
Cadium	Mercury	Thallium
Chromium	Nickel	Zinc

(USEPA, 1993c:61587)

Appendix B

Toxic Pollutants and Hazardous Substances

Acetaldehyde	Isopropanolamine dodecylbenzenesulfonate
Allyl alcohol	Kelthane
Allyl chloride	Kepone
Amyl acetate	Malathion
Anitine	Mercaptodimethur
Asbestos	Methyl mercaptan
Benzonitrile	Methyl methacrylate
Benzyl Chloride	Methyl parathion
Butyl acetate	Mevinphos
Butylamine	Mexacarbate
Captan	Monoethyl amine
Carbaryl	Monomethyl amine
Carbofuran	Naled
Carbon disulfide	Napthenic acid
Chlorpyrifos	Nitrotoluene
Coumaphos	Parathion
Cresol	Phenosulfanate
Crotoaldehyde	Phosgene
Cyclohexane	Propargite
2,4-Dichlorophenoxy Acetic acid	Propylene oxide
Diazinon	Pyrethrine
Dicamba	Quinoline
Dichlobenil	Resorcinol
Dichlone	Strontium
2,2-Dichloropropionic acid	Strychnine
Dichlorvos	Styrene
Diethyl amine	2,4,5-Trichlorophenoxy acetic acid
Dimethyl amine	TDE
Dintrobenzene	2,4,5-Trichlorophenoxy
Diquat	Trichlorofan
Disulfoton	Triethanolamine dodecylbenzenesulfonate
Diuron	Triethylamine
Epichlorohydin	Trimethylamine
Ethion	Uranium
Ethylene diamine	Vanadium
Ethylene dibromide	Vinyl acetate
Formaldehyde	Xylene
Furforal	Xylenol
Guthion	Zirconium
Isoprene	(USEPA, 1993c:61587-61588)

Appendix C:
Air Forces Bases That Applied For the Group Permit

Altus AFB	Lackland AFB
Arnold AFB	Laughlin AFB
Barksdale AFB	Loring AFB
Bergstrom AFB	Lowry AFB
Brooks AFB	Malmstrom AFB
Cannon AFB	McChord AFB
Cape Canaveral AFB	McConnell AFB
Carswell AFB	Minot AFB
Chanute AFB	Moody AFB
Charleston AFB	Mountain Home AFB
Columbus AFB	Myrtle Beach AFB
Davis-Monthan AFB	Nellis AFB
Dobbins AFB	Newark AFB
Dover AFB	Offutt AFB
Dyess AFB	Patrick AFB
Eaker AFB	Peterson AFB
Eglin AFB	Pope AFB
Eielson FB	Randolf AFB
Ellsworth AFB	Reese AFB
Elmendorf AFB	Robins AFB
England AFB	Scott AFB
Fairchild AFB	Seymour Johnson AFB
Goodfellow AFB	Shaw AFB
Grand Forks AFB	Shemya AFB
Hanscom AFB	Sheppard AFB
Hickam AFB	Tinker AFB
Holloman AFB	Vance AFB
Keesler AFB	Westover AFB
Kelly AFB	Williams AFB
KI Sawyer AFB	Wright-Patterson AFB
Kirtland AFB	Wurtsmith AFB
	(Combs, 1994)

Appendix D: E-Mail Message

My name is Lynne Urquhart. I am a Master's student in Environmental Engineering at the Air Force Institute of Technology (AFIT). I am attempting to contact the environmental flight chief at your base. If you have received this message in error, please forward a copy to your environmental flight chief. Thank you.

I am now working on my thesis which deals with nonpoint source pollution transported by stormwater. I wish to evaluate how well the Air Force is meeting the current stormwater control standards and how well it will meet the stricter standards coming in the future. I hope to get enough information to support some conclusions about the Air Force's future in stormwater control.

In order to do this I am requesting data from a number of Air Force bases in the United States. If you could answer the following questions, your help would be greatly appreciated.

1) Do you test the stormwater on your base?
2) How often?
3) What contaminants do you test for?
4) At what concentrations have these contaminants been detected in 1993 and 1994? I WOULD GREATLY APPRECIATE COPIES OF THIS DATA IF YOU HAVE IT.
5) What stormwater standards is your base expected to meet by federal regulations? State regulations? Local regulations?
6) Can you provide any further information to clarify the above data? If so, what?
7) What is the name and number of a person I may contact if I have any questions?

If you have data to send me that is not available on the WANG system please mail it to this address:

Lynne Adams Urquhart
AFIT/ENV
2950 P Street
Wright-Patterson AFB, OH 45433-7765

Please respond as soon as possible, I need to begin my evaluation by the end of April. If you would like a copy of my thesis when I am finished please let me know and I will see if that can be arranged. If you have any other questions or comments, I can be reached through the Wang or by voice mail, DSN 785-3636 ext. 1485 or commercial 513-255-3636 ext. 1485. Thank you for your time and any help you can give me.

Lynne Urquhart

Appendix E: AF Bases Sent Message

AF Academy	Laughlin AFB
Altus AFB	Little Rock AFB
Andrews AFB	Loring AFB
Arnold AFB	Los Angeles AFB
Barksdale AFB	Luke AFB
Beale AFB	MacDill AFB
Bolling AFB	Malmstrom AFB
Brooks AFB	March AFB
Cannon AFB	Maxwell AFB
Carswell AFB	McChord AFB
Castle AFB	McClellan AFB
Charleston AFB	McConnell AFB
Cheyenne Mountain	McGuire AFB
Columbus AFB	Minot AFB
Davis-Monthan AFB	Moody AFB
Dobbins AFB	Mountain Home AFB
Dover AFB	Nellis AFB
Dyess AFB	Newark AFB
Edwards AFB	Offutt AFB
Eglin AFB	Onizua AFB
Eielson FB	Patrick AFB
Ellsworth AFB	Peterson AFB
Elmendorf AFB	Plattsburg AFB
Fairchild AFB	Pope AFB
Falcon AFB	Randolf AFB
FE Warren AFB	Reese AFB
Goodfellow AFB	Robins AFB
Grand Forks AFB	Richards-Gebaur AFB
Griffis AFB	Scott AFB
Grissom AFB	Seymour Johnson AFB
Hanscom AFB	Shaw AFB
Hickam AFB	Sheppard AFB
Hill AFB	Tinker AFB
Holloman AFB	Travis AFB
Hurlburt Field	Tyndall AFB
Keesler AFB	Vance AFB
Kelly AFB	Vandenburg AFB
KI Sawyer AFB	Westover AFB
Kirtland AFB	Whiteman AFB
Lackland AFB	Wright-Patterson AFB
Langley AFB	

Appendix F: Responding AF Bases Sampling Program

BASE	COM	EPA	DATA	FREQ.	Comment
ARTN	AFSC	IV	no		48 MGD industrial effluent
BODC		III	no		
COMS	AETC	IV	no		
DOGA	RES	IV	no		
EDCA	AFMC	IX	no		Lowest point in valley
FEWY	SPCM	VIII	no		sample upon state request
GOTX	AETC	VI	no	env/bio	
HAMA	AFMC	I	no		
HONM	ACC	VI	no		group application
KIMI	ACC	V	no		
KINM	AFMC	VI	no	2/year	start biannual testing in July
LATX	AETC	VI	no	annual	No 93 data
MCKS	AMC	VII	no		Only data for spills
NENV	ACC	IX	no	-----	
OFNB	ACC	VII	no		stream data only
PECO	SPCM	VIII	no		
PONC	ACC	IV	no		stream data only
SENC	ACC	IV	no		
CACA	ACC	IX	yes	2/year	
MIND	ACC	VIII	yes	4 times	
ALOK	AETC	VI	yes	once	Group permit spring 93
ANMD	AMC	III	yes	once	
DAAZ	ACC	IX	yes	once	No data - comm problems
EGFL	AFMC	IV	yes	once	No data received
ELAK	PACAF	X	yes	once	
HUFL		IV	yes	once	No data - comm problems
KEMS	AETC	IV	yes	once	
MCCA	AFMC	IX	yes	once	
SHTX	AETC	VI	yes	once	No data received
RETX	AETC	VI	yes	annual	
ROGA	AFMC	IV	yes	annual	No data received
GRND	AMC	VIII	yes	quarterly	
GRIN	ACC	V	yes	quarterly	
MAFL	ACC	IV	yes	quarterly	
MAID	AMC	X	yes	quarterly	
PAFL	SPCM	IV	yes	quarterly	
TYFL	AETC	IV	yes	quarterly	No data received
WEMA	RES	I	yes	quarterly	
CATX	ACC	VI	yes	monthly	No data - comm problems
ELSD	ACC	VIII	yes	monthly	
FAWA	AMC	X	yes	monthly	
GUAL	AETC	IV	yes	monthly	
KETX	AFMC	VI	yes	monthly	
LIAR	AMC	VI	yes	monthly	
RATX	AETC	VI	yes	monthly	No data received
SHSC	ACC	IV	yes	monthly	
WROH	AFMC	V	yes	monthly	
MAAL	AETC	IV	yes	biweekly	
GRNY	ACC	II	yes	weekly	
TIOK	AFMC	VII	yes	weekly	

Appendix G: Compressed Data From Bases

BASE	COM	EPA	Freq	Outfall	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	TKN (mg/L)	N+N Nitrogen (mg/L)	Phosphorus, Total (mg/L)	pH (s.u.)	1,1,1-Trichloroethane (mg/L)	Acrylonitrile (mg/L)	Aluminum (ug/L)	Ammonia Nitrogen (mg/L)	Antimony, Total (ug/L)	Arsenic, Total (ug/L)	Barium, Total (ug/L)	Benzene (ug/L)	Beryllium, Total (ug/L)	Butylbenzyl Phthalate (mg/L)	Cadmium (ug/L)	Chloride(mg/L)	Copper, Total (ug/L)	Dimethyl Phthalate (mg/L)	Ethylbenzene (ug/L)	Fluoranthene (mg/L)
					Conventional Pollutants							Unconventional Pollutants															
					9	65	100	105	0.68	0.33	6.5	3.1	7.55	750	19	88	0.018	1000	0.0053	130	3	1.8	0.009	9	313	32000	3.98
											9.0																
ALOK	AETC	VI	CY 93, QTR 2	001		146	432	2	1.04	0.46																	
ALOK	AETC	VI	CY 93, QTR 2	002		225	165	3	1.22	0.45																	
ALOK	AETC	VI	CY 93, QTR 2	003		58	548	1	1.23	0.36																	
ALOK	AETC	VI	CY 93, QTR 2	004		160	522	1	2.46	0.27																	
ANMD	AMC	III	CY 92, QTR 3	E	27	112	256	2								<5	<5			<5		<5		<25			
ANMD	AMC	III	CY 92, QTR 1	G																							
ANMD	AMC	III	CY 93, QTR 2	K	9	140	161	2		1.23		<5				<5	<5			5		10.5		29.0		<5	
ANMD	AMC	III	CY 93, QTR 2	L	21	107	59	3		0.18						<5	<5			<5		11.0		54.0			
ANMD	AMC	III	CY 92, QTR 3	O	25	50	161	2								<5	<5			<5		<5		27.0			
CACA	ACC	IX	CY 92, QTR 4		32		31				7.3								ND							ND	
CACA	ACC	IX	CY 93, QTR 1		27		20				8.2								ND							ND	
CACA	ACC	IX	CY 93, QTR 4		6		0				7.2								<.30							<.30	
CACA	ACC	IX	CY 94, QTR 1																<.30							<.30	
CACA	ACC	IX	CY 93, QTR 1	BCE	12		6				8.3								ND							ND	
CACA	ACC	IX	CY 93, QTR 4	BCE	14		0				6.5								<.30							<.30	
CACA	ACC	IX	CY 94, QTR 1	BCE															<.30							<.30	
ELSD	ACC	VIII	CY 93, QTR 1	001	3						7.2																
ELSD	ACC	VIII	CY 93, QTR 2	001	2						7.4																
ELSD	ACC	VIII	CY 93, QTR 3	001							7.7																
ELSD	ACC	VIII	CY 93, QTR 4	001	3						7.7																
ELSD	ACC	VIII	CY 93, QTR 1	002	<1						7.3																
ELSD	ACC	VIII	CY 93, QTR 2	002	2						7.3																
ELSD	ACC	VIII	CY 93, QTR 3	002							7.4																
ELSD	ACC	VIII	CY 93, QTR 4	002	1						7.6																
ELSD	ACC	VIII	CY 93, QTR 1	003	52						7.6																
ELSD	ACC	VIII	CY 93, QTR 2	003	NF						7.6																
ELSD	ACC	VIII	CY 93, QTR 3	003							7.1																
ELSD	ACC	VIII	CY 93, QTR 4	003	NF						NF																
ELAK	PACAF	X	CY 92, QTR 3	002	15	35	195	7		0.23				2400													
ELAK	PACAF	X	CY 92, QTR 3	003	25	38	29	1		ND				550					18							44	
ELAK	PACAF	X	CY 92, QTR 3	004	13	ND	16	ND		ND				370													
ELAK	PACAF	X	CY 92, QTR 3	007	36	ND	4	0		ND																	
ELAK	PACAF	X	CY 92, QTR 3	008	ND	10	44	0		ND				1800													
ELAK	PACAF	X	CY 92, QTR 3	010	42	18	6	0		ND																	
FAWA	AMC	X	CY 93, QTR 1	001	8		81				5.7																
FAWA	AMC	X	CY 93, QTR 2	001	6		4				7.4																
FAWA	AMC	X	CY 93, QTR 3	001	6		6				8.1																
FAWA	AMC	X	CY 93, QTR 4	001	7		14				8.1																
GRND	AMC	VII	CY 93, QTR 1	001		NF		NF	0.20	0.47	8.5				0		10					1.0	44.0	20.0			
GRND	AMC	VII	CY 93, QTR 2	001		56		1	3.10	0.10	6.0				0							1.0	245.0	20.0			
GRND	AMC	VII	CY 93, QTR 3	001		25		1	1.12	0.00	7.0				0		0					0.0	0.0	0.0			
GRND	AMC	VII	CY 93, QTR 4	001		61		1	0.70	0.10	7.5				1		30					1.0	190.0	20.0			

GRND	AMC	VII	CY 93, QTR 1	002			NF		NF		NF	NF				NF		NF					NF	NF	NF			
GRND	AMC	VII	CY 93, QTR 2	002			31		1	0.61	0.11	6.0				0		10					1.0	18.0	20.0			
GRND	AMC	VII	CY 93, QTR 3	002			25		1	3.55	0.10	7.0				0		10					1.0	74.0	20.0			
GRND	AMC	VII	CY 93, QTR 4	002			68		1	2.92	0.10	7.6				0		10					1.0	72.0	20.0			
GRND	AMC	VII	CY 93, QTR 1	003			NF		NF		NF					NF		NF					NF	NF	NF			
GRND	AMC	VII	CY 93, QTR 2	003			17		1	3.82	0.12	6.0				0		10					1.0	45.0	20.0			
GRND	AMC	VII	CY 93, QTR 3	003			35		1	2.06	0.10	7.0				0		10					1.0	260.0	20.0			
GRND	AMC	VII	CY 93, QTR 4	003			66		1	1.20	0.16	7.8				0		10					1.0	260.0	20.0			
GRND	AMC	VII	CY 93, QTR 1	040			NF		NF			NF																
GRND	AMC	VII	CY 93, QTR 2	040			11		1	0.30		6.0																
GRND	AMC	VII	CY 93, QTR 3	040			20		1	3.42		7.6																
GRND	AMC	VII	CY 93, QTR 4	040			90		1	0.84		7.0																
GRND	AMC	VII	CY 93, QTR 1	041			NF		NF			NF																
GRND	AMC	VII	CY 93, QTR 2	041			10		1	3.82		5.0																
GRND	AMC	VII	CY 93, QTR 3	041			31		1	4.82		7.0																
GRND	AMC	VII	CY 93, QTR 4	041			27		1	1.82		7.6																
GRND	AMC	VII	CY 93, QTR 1	042			NF		NF			NF																
GRND	AMC	VII	CY 93, QTR 2	042			56		2	0.48		6.0																
GRND	AMC	VII	CY 93, QTR 3	042			12		1	2.02		7.0																
GRND	AMC	VII	CY 93, QTR 4	042			19		1	2.62		7.8																
GRND	AMC	VII	CY 93, QTR 1	043			NF		NF			NF																
GRND	AMC	VII	CY 93, QTR 2	043			NF		NF			NF																
GRND	AMC	VII	CY 93, QTR 3	043			31		2	0.18		7.0																
GRND	AMC	VII	CY 93, QTR 4	043			19		1	1.02		7.6																
GRND	AMC	VII	CY 93, QTR 1	053			NF		NF			NF																
GRND	AMC	VII	CY 93, QTR 2	053			11		1	1.02		5.0																
GRND	AMC	VII	CY 93, QTR 3	053			19		2	2.38		6.0																
GRND	AMC	VII	CY 93, QTR 4	053			29		2	1.72		7.0																
GRNY	ACC	II	CY 93, QTR 1	001				15				7.9			1190										26.5			
GRNY	ACC	II	CY 93, QTR 2	001				4				8.0			1543										9.4			
GRNY	ACC	II	CY 93, QTR 3	001				3				8.0			245										<20			
GRNY	ACC	II	CY 93, QTR 4	001				3				7.8			540										11.0			
GRNY	ACC	II	CY 93, QTR 1	002								8.3																
GRNY	ACC	II	CY 93, QTR 2	002								8.1																
GRNY	ACC	II	CY 93, QTR 3	002								7.9																
GRNY	ACC	II	CY 93, QTR 4	002								7.5																
GRNY	ACC	II	CY 93, QTR 1	003		4			0	0.48		6.8				<0.01												
GRNY	ACC	II	CY 93, QTR 2	003		1			1	0.80		7.0				<0.01												
GRNY	ACC	II	CY 93, QTR 3	003		2			6	0.50		6.5				1												
GRNY	ACC	II	CY 93, QTR 4	003		2			1	0.74		6.4				<0.01												
GRNY	ACC	II	CY 93, QTR 1	004		3			0	1.36		7.1				<0.1												
GRNY	ACC	II	CY 93, QTR 2	004		<1.0			1	1.38		6.7				<0.1												
GRNY	ACC	II	CY 93, QTR 3	004		<1.0			3	1.30		7.3				<0.1												
GRNY	ACC	II	CY 93, QTR 4	004		<1.0			1	1.34		7.4				<0.1												
GRNY	ACC	II	CY 93, QTR 1	010								7.8																
GRNY	ACC	II	CY 93, QTR 2	010								6.7																
GRNY	ACC	II	CY 93, QTR 3	010								7.3																
GRNY	ACC	II	CY 93, QTR 4	010								6.9																
GRNY	ACC	II	CY 93, QTR 2	020								7.1																
GRNY	ACC	II	CY 93, QTR 3	020								7.6																
GRNY	ACC	II	CY 93, QTR 4	020								7.1																
GRNY	ACC	II	CY 93, QTR 2	021								7.6																
GRNY	ACC	II	CY 93, QTR 3	021								7.5																
GRNY	ACC	II	CY 93, QTR 4	021								7.5																
GRNY	ACC	II	CY 93, QTR 2	022								7.9																
GRNY	ACC	II	CY 93, QTR 3	022								8.0																
GRNY	ACC	II	CY 93, QTR 4	022								8.0																
GRNY	ACC	II	CY 93, QTR 1	030					0	0.58		7.4				0												
GRNY	ACC	II	CY 93, QTR 2	030					1	0.50		6.9				1												
GRNY	ACC	II	CY 93, QTR 3	030								7.6																
GRNY	ACC	II	CY 93, QTR 4	030					1	0.42		7.3				<0.1												
GRNY	ACC	II	CY 93, QTR 1	031					0	0.86		7.9				0												
GRNY	ACC	II	CY 93, QTR 2	031					1	1.55		7.4				1												
GRNY	ACC	II	CY 93, QTR 3	031								7.8							<0.2									

GRNY	ACC	II	CY 93, QTR 4	031					1	0.90						<0.1												
GRNY	ACC	II	CY 93, QTR 1	096		1			0	0.79		8.0				<0.1												
GRNY	ACC	II	CY 93, QTR 2	096		1			1	1.80		6.0				<0.1												
GRNY	ACC	II	CY 93, QTR 3	096		2			2	0.77		7.2				<0.1												
GRNY	ACC	II	CY 93, QTR 4	096		<1.0			1	0.49		6.5				<0.1												
GRIN	ACC	V	CY 93, QTR 1	002				4				8.4																
GRIN	ACC	V	CY 93, QTR 2	002				8				8.7																
GRIN	ACC	V	CY 93, QTR 3	002				8				8.7																
GRIN	ACC	V	CY 93, QTR 4	002				5				8.6																
GRIN	ACC	V	CY 93, QTR 1	003				5				8.2																
GRIN	ACC	V	CY 93, QTR 2	003				10				8.5																
GRIN	ACC	V	CY 93, QTR 3	003				11				8.4																
GRIN	ACC	V	CY 93, QTR 4	003				8				8.4																
GUAL	AETC	IV	CY 92, QTR 3	001				ND				ND																
GUAL	AETC	IV	CY 92, QTR 4	001				5				7.317																
GUAL	AETC	IV	CY 93, QTR 1	001				130				7.533																
GUAL	AETC	IV	CY 93, QTR 2	001				13				7.533																
GUAL	AETC	IV	CY 93, QTR 3	001				7				7.625																
GUAL	AETC	IV	CY 92, QTR 3	002				94				7.4																
GUAL	AETC	IV	CY 92, QTR 4	002				24				7.4																
GUAL	AETC	IV	CY 93, QTR 1	002				9				7.5																
GUAL	AETC	IV	CY 93, QTR 2	002				ND																				
GUAL	AETC	IV	CY 93, QTR 3	002				8				7.8																
GUAL	AETC	IV	CY 92, QTR 3	003				5			ND	ND																
GUAL	AETC	IV	CY 92, QTR 4	003				ND			ND	ND																
GUAL	AETC	IV	CY 93, QTR 1	003				ND			ND	ND																
GUAL	AETC	IV	CY 93, QTR 2	003				86			0	7.55																
GUAL	AETC	IV	CY 93, QTR 3	003				14			1	7.575																
GUAL	AETC	IV	CY 92, QTR 3	004				ND				ND																
GUAL	AETC	IV	CY 92, QTR 4	004				ND				ND																
GUAL	AETC	IV	CY 93, QTR 1	004				65				7.3																
GUAL	AETC	IV	CY 93, QTR 2	004				0				7.4																
GUAL	AETC	IV	CY 93, QTR 3	004				0				7.7																
KEMI	AETC	IV	CY 93, QTR 3	001		5	<10	51	1	0.16	0.19							21					<1					
KEMI	AETC	IV	CY 93, QTR 3	002		4	35	2259	1	0.46	<10						39	<10			<10		<5		<50			
KEMI	AETC	IV	CY 93, QTR 3	003		1	25	2299	1	0.60	0.13						15				<10				<50			
KEMI	AETC	IV	CY 93, QTR 3	004		2	25	8186	1	0.10	<10						20	11			<10				<50			
KEMI	AETC	IV	CY 93, QTR 3	005		4	<10	817	1	0.16	<10						39				<10				<50			
KEMI	AETC	IV	CY 93, QTR 3	006		5	<10	138	1	0.22	0.13							<10							<50			
KETX	AFMC	VI	CY 93, QTR 2	002			199	62				9.1											5.0		19.0			
KETX	AFMC	VI	CY 93, QTR 3	002			132	28				8.7																
KETX	AFMC	VI	CY 93, QTR 4	002			74					8.3											<10		80.0			
KETX	AFMC	VI	CY 93, QTR 3	004			83					8.2											<10		<50			
KETX	AFMC	VI	CY 93, QTR 4	004			47					8.7											<10		<50			
KETX	AFMC	VI	CY 93, QTR 3	006			20					8.1																
KETX	AFMC	VI	CY 93, QTR 3	007			30					8.1																
KETX	AFMC	VI	CY 93, QTR 2	008																								
KETX	AFMC	VI	CY 93, QTR 3	008																								
LIAR	AMC	VI	CY 93, QTR 1	001			14					7.5																
LIAR	AMC	VI	CY 93, QTR 2	001			23					7.6																
LIAR	AMC	VI	CY 93, QTR 3	001			14					7.3																
LIAR	AMC	VI	CY 93, QTR 4	001			20					7.5																
LIAR	AMC	VI	CY 93, QTR 1	002			20					7.5																
LIAR	AMC	VI	CY 93, QTR 2	002			23					8.2																
LIAR	AMC	VI	CY 93, QTR 3	002			NF					NF																
LIAR	AMC	VI	CY 93, QTR 4	002			42					7.6																
LIAR	AMC	VI	CY 93, QTR 1	004			14					7.2																
LIAR	AMC	VI	CY 93, QTR 2	004			19					7.3																
LIAR	AMC	VI	CY 93, QTR 3	004			NF					NF																
LIAR	AMC	VI	CY 93, QTR 4	004			25					7.8																
MAFL	ACC	IV	CY 93, QTR 1	001				36				6.7																
MAFL	ACC	IV	CY 93, QTR 2	001				18				6.8																
MAFL	ACC	IV	CY 93, QTR 3	002				9				7.1																
MAFL	ACC	IV	CY 93, QTR 4	002				61				7.4																

MAFL	ACC	IV	CY 93, QTR 1	002				24				7.1																
MAFL	ACC	IV	CY 93, QTR 2	002				48				7.0																
MAFL	ACC	IV	CY 93, QTR 3	004				8				7.2																
MAFL	ACC	IV	CY 93, QTR 4	004				73				7.4																
MAFL	ACC	IV	CY 93, QTR 1	004				38				7.1																
MAFL	ACC	IV	CY 93, QTR 2	004				32				7.2																
MAFL	ACC	IV	CY 93, QTR 3	005				26				7.3																
MAFL	ACC	IV	CY 93, QTR 4	005				80				7.3																
MAFL	ACC	IV	CY 93, QTR 1	005				43				7.2																
MAFL	ACC	IV	CY 93, QTR 2	005				40				7.2																
MAFL	ACC	IV	CY 93, QTR 3	007				24				7.4																
MAFL	ACC	IV	CY 93, QTR 4	007				87				7.4																
MAFL	ACC	IV	CY 93, QTR 1	007				25				7.2																
MAFL	ACC	IV	CY 93, QTR 2	007				17				7.4																
MAFL	ACC	IV	CY 93, QTR 3	008				31				7.3																
MAFL	ACC	IV	CY 93, QTR 4	008				92				7.6																
MAFL	ACC	IV	CY 93, QTR 1	008				51				7.7																
MAFL	ACC	IV	CY 93, QTR 2	008				31				7.8																
MAFL	ACC	IV	CY 93, QTR 3	008				51				7.7																
MAFL	ACC	IV	CY 93, QTR 4	008				31				7.8																
MAID	AMC	X	CY 93, QTR 3	SP2						1.70																		
MAID	AMC	X	CY 93, QTR 4	SP2						1.40																		
MAID	AMC	X	CY 93, QTR 3	SP3						1.90																		
MAID	AMC	X	CY 93, QTR 4	SP3						1.36																		
MAID	AMC	X	CY 93, QTR 3	SP4						0.00																		
MAID	AMC	X	CY 93, QTR 4	SP4						1.48																		
MAID	AMC	X	CY 93, QTR 3	SP5						0.00																		
MAID	AMC	X	CY 93, QTR 4	SP5						0.18																		
MAAL	AETC	IV	CY 92, QTR 3	001				107																				
MAAL	AETC	IV	CY 92, QTR 4	001				15																				
MAAL	AETC	IV	CY 93, QTR 1	001				15																				
MAAL	AETC	IV	CY 93, QTR 2	001				26																				
MAAL	AETC	IV	CY 93, QTR 3	001				13																				
MAAL	AETC	IV	CY 92, QTR 3	002				ND			ND																	
MAAL	AETC	IV	CY 92, QTR 4	002				5			0																	
MAAL	AETC	IV	CY 93, QTR 1	002				15			0																	
MAAL	AETC	IV	CY 93, QTR 2	002				ND			ND																	
MAAL	AETC	IV	CY 93, QTR 3	002				62			1																	
MAAL	AETC	IV	CY 92, QTR 3	003				ND			ND																	
MAAL	AETC	IV	CY 92, QTR 4	003				16			0																	
MAAL	AETC	IV	CY 93, QTR 1	003				6			0																	
MAAL	AETC	IV	CY 93, QTR 2	003				15			1																	
MAAL	AETC	IV	CY 93, QTR 3	003				47			3																	
MAAL	AETC	IV	CY 92, QTR 3	005				97																				
MAAL	AETC	IV	CY 92, QTR 4	005				51																				
MAAL	AETC	IV	CY 93, QTR 1	005				20																				
MAAL	AETC	IV	CY 93, QTR 2	005				8																				
MAAL	AETC	IV	CY 93, QTR 3	005				15																				
MAAL	AETC	IV	CY 92, QTR 3	006		0		9																				
MAAL	AETC	IV	CY 92, QTR 4	006		0		54																				
MAAL	AETC	IV	CY 93, QTR 1	006		0		13																				
MAAL	AETC	IV	CY 93, QTR 2	006		4		9																				
MAAL	AETC	IV	CY 93, QTR 3	006		25		4																				
MAAL	AETC	IV	CY 92, QTR 3	008				55																				
MAAL	AETC	IV	CY 92, QTR 4	008				ND																				
MAAL	AETC	IV	CY 93, QTR 1	008				ND																				
MAAL	AETC	IV	CY 93, QTR 2	008				ND																				
MAAL	AETC	IV	CY 93, QTR 3	008				ND																				
MCCA	AFMC	IX	CY 93, QTR 4	A			206	115				7.2	<.17							<.12			12.0		75.0		<.18	
MCCA	AFMC	IX	CY 93, QTR 4	Magpie			186	25				7.1	<.17							<.12			1.0		20.0		<.18	
MCCA	AFMC	IX	CY 93, QTR 4	Second			280	55				7.1	<.17							<.12			2.0		36.0		2	
MCCA	AFMC	IX	CY 93, QTR 4	#7			201	30				7.4	<.17							<.12			2.0		20.0		<.18	
MIND	ACC	VII	CY 94, QTR 1	Ditch A		20	38	6	8	1.00	0.30	7.7																
MIND	ACC	VII	CY 94, QTR 1	Ditch B		11	33	21	<5	<1	0.32	7.6																

MIND	ACC	VII	CY 94, QTR 1	NW Ditch		<6	37	26	<5	<1	0.32	7.9																
MIND	ACC	VII	CY 94, QTR 1	SAC Ramp		44	50	4	5	1.20	0.28	7.7																
PAFL	SPCM	IV	CY 93, QTR 2	18"				NF				NF																
PAFL	SPCM	IV	CY 93, QTR 3	18"				NF				NF																
PAFL	SPCM	IV	CY 93, QTR 4	18"				NF				NF																
PAFL	SPCM	IV	CY 94, QTR 1	18"				32				7.9																
PAFL	SPCM	IV	CY 93, QTR 2	36"				21				6.0																
PAFL	SPCM	IV	CY 93, QTR 3	36"				4				6.0																
PAFL	SPCM	IV	CY 93, QTR 4	36"				38				6.0																
PAFL	SPCM	IV	CY 94, QTR 1	36"				86				7.8																
PAFL	SPCM	IV	CY 93, QTR 2	54"				20				6.0																
PAFL	SPCM	IV	CY 93, QTR 3	54"				6				7.0																
PAFL	SPCM	IV	CY 93, QTR 4	54"				34				7.0																
PAFL	SPCM	IV	CY 94, QTR 1	54"				7				7.0																
PAFL	SPCM	IV	CY 93, QTR 2	Fire				19				6.0																
PAFL	SPCM	IV	CY 93, QTR 3	Fire				6				6.0																
PAFL	SPCM	IV	CY 93, QTR 4	Fire				11				6.0																
PAFL	SPCM	IV	CY 94, QTR 1	Fire				7				7.9																
PAFL	SPCM	IV	CY 93, QTR 2	POL				29				6.0																
PAFL	SPCM	IV	CY 93, QTR 3	POL								6.0																
PAFL	SPCM	IV	CY 93, QTR 4	POL								6.0																
PAFL	SPCM	IV	CY 94, QTR 1	POL				16				7.0																
RETX	AETC	VI	CY 94, QTR 2	001		16	68	72				7.7																
RETX	AETC	VI	CY 94, QTR 2	002		24	123	73				8.3																
RETX	AETC	VI	CY 94, QTR 2	003		37	355	34				8.2																
RETX	ACC	IV	CY 93, QTR 1	002				5				7.6																
SHSC	ACC	IV	CY 93, QTR 2	002				5				6.9																
SHSC	ACC	IV	CY 93, QTR 3	002				11				6.8																
SHSC	ACC	IV	CY 93, QTR 4	002				2				6.5																
SHSC	ACC	IV	CY 93, QTR 1	003				11				7.9																
SHSC	ACC	IV	CY 93, QTR 2	003				11				7.1																
SHSC	ACC	IV	CY 93, QTR 3	003				14				6.3																
SHSC	ACC	IV	CY 93, QTR 4	003				16				7.2																
TIOK	AFMC	VI	CY 93, QTR 1	002				17				8.4																
TIOK	AFMC	VI	CY 93, QTR 2	002				17				8.2																
TIOK	AFMC	VI	CY 93, QTR 3	002				22				8.2																
TIOK	AFMC	VI	CY 93, QTR 4	002				12				8.1																
TIOK	AFMC	VI	CY 93, QTR 1	006								8.7			0													
TIOK	AFMC	VI	CY 93, QTR 2	006								8.1			0													
TIOK	AFMC	VI	CY 93, QTR 3	006								8.1			0													
TIOK	AFMC	VI	CY 93, QTR 4	006								8.2			0													
TIOK	AFMC	VI	CY 93, QTR 1	007								8.2			2													
TIOK	AFMC	VI	CY 93, QTR 2	007								7.9			0													
TIOK	AFMC	VI	CY 93, QTR 3	007								8.2			0													
TIOK	AFMC	VI	CY 93, QTR 4	007								8.0			0													
TIOK	AFMC	VI	CY 93, QTR 1	008								8.4																
TIOK	AFMC	VI	CY 93, QTR 2	008								7.5																
TIOK	AFMC	VI	CY 93, QTR 3	008								7.7																
TIOK	AFMC	VI	CY 93, QTR 4	008								7.3																
TIOK	AFMC	VI	CY 93, QTR 1	009		15	33					7.8			2													
TIOK	AFMC	VI	CY 93, QTR 2	009		5	19					7.8			0													
TIOK	AFMC	VI	CY 93, QTR 3	009		6	20					8.0			0													
TIOK	AFMC	VI	CY 93, QTR 4	009		6	16					7.9			0													
WEMA		I	CY 93, QTR 1	001								6.5																
WEMA		I	CY 93, QTR 2	001								6.5																
WEMA		I	CY 93, QTR 4	001								6.6																
WEMA		I	CY 93, QTR 1	002								6.3																
WEMA		I	CY 93, QTR 2	002								6.6																
WEMA		I	CY 93, QTR 4	002								6.8																
WROH	AFMC	V	CY 93, QTR 1	001				NF				NF																
WROH	AFMC	V	CY 93, QTR 2	001				NF				NF																
WROH	AFMC	V	CY 93, QTR 3	001				NF				NF																
WROH	AFMC	V	CY 93, QTR 4	001				NF				NF																
WROH	AFMC	V	CY 93, QTR 1	002				24				8.1																

WROH	AFMC	V	CY 93, QTR 2	002				108				7.9																
WROH	AFMC	V	CY 93, QTR 3	002				114				7.9																
WROH	AFMC	V	CY 93, QTR 4	002				20				8.3																
WROH	AFMC	V	CY 93, QTR 1	003				35				8.2													11.0			
WROH	AFMC	V	CY 93, QTR 2	003				13				8.1													33.0			
WROH	AFMC	V	CY 93, QTR 3	003				28				8.1													39.0			
WROH	AFMC	V	CY 93, QTR 4	003				7				8.3													16.0			
WROH	AFMC	V	CY 93, QTR 1	004				2				8.1																
WROH	AFMC	V	CY 93, QTR 2	004				8				8.1																
WROH	AFMC	V	CY 93, QTR 3	004				2				7.9																
WROH	AFMC	V	CY 93, QTR 4	004				2				8.1																
WROH	AFMC	V	CY 93, QTR 1	005				6				8.3																
WROH	AFMC	V	CY 93, QTR 2	005				6				8.2																
WROH	AFMC	V	CY 93, QTR 3	006				<2				8.0																
WROH	AFMC	V	CY 93, QTR 4	006				<2				8.3																
WROH	AFMC	V	CY 93, QTR 1	008				NF				NF																
WROH	AFMC	V	CY 93, QTR 2	008				NF				NF																
WROH	AFMC	V	CY 93, QTR 3	008				NF				NF																
WROH	AFMC	V	CY 93, QTR 4	008				NF				NF																
			data			62	86	182	74	64	49	251	5	0	20	30	8	19	1	12	8	0	26	12	37	0	13	0
			#s			53	70	156	62	62	33	224	0	0	20	15	4	11	0	1	1	0	17	10	26	0	2	0
						0.40	0.29	0.12	0.00	0.68	0.33	0.11	ERR	ERR	0.20	0.00	0.00	0.91	ERR	1.00	0.00	ERR	0.35	0.90	0.96	ERR	0.00	ERR

BASE	COM	EPA	Freq	Outfall	Iron, Total (ug/L)	Lead, Total (ug/L)	Manganese (ug/L)	Mercury, Total (ug/L)	Methylene Chloride (mg/L)	Naphthalene (mg/L)	Nickle, total (ug/L)	PCB-1016 (ug/L)	PCB-1221 (ug/L)	PCB-1232 (ug/L)	PCB-1242 (ug/L)	PCB-1248 (ug/L)	PCB-1254 (ug/L)	PCB-1260 (ug/L)	Phenanthrene (mg/L)	Phenols, Total (ug/L)	Pyrene (ug/L)	Selenium (ug/L)	Silver, Total (ug/L)	Toulene (ug/L)	Trichloroethylene (mg/L)	Zinc, Total (ug/L)
					300	33.7	50	2.4	4.7	2.3	788.4	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.00044	0.03	10.2	0.0028	20	0.9	17500	45	65
ALOK	AETC	VI	CY 93, QTR 2	001																						
ALOK	AETC	VI	CY 93, QTR 2	002																						
ALOK	AETC	VI	CY 93, QTR 2	003																						
ALOK	AETC	VI	CY 93, QTR 2	004																						
ANMD	AMC	III	CY 92, QTR 3	E		31		<.2			<40	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0		61		<5	<10			326
ANMD	AMC	III	CY 92, QTR 1	G								<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0								
ANMD	AMC	III	CY 93, QTR 2	K		17		<.2	11		<40									<50		<5	223			95
ANMD	AMC	III	CY 93, QTR 2	L		25		<.2			40									<50		<5	<10			133
ANMD	AMC	III	CY 92, QTR 3	O		22		<.2			<40									ND		<5	<10			116
CACA	ACC	IX	CY 92, QTR 4																					ND		
CACA	ACC	IX	CY 93, QTR 1																					ND		
CACA	ACC	IX	CY 93, QTR 4																					<.30		
CACA	ACC	IX	CY 94, QTR 1																					<.30		
CACA	ACC	IX	CY 93, QTR 1	BCE																				ND		
CACA	ACC	IX	CY 93, QTR 4	BCE																				<.30		
CACA	ACC	IX	CY 94, QTR 1	BCE																				<.30		
ELSD	ACC	VII	CY 93, QTR 1	001						ND																
ELSD	ACC	VII	CY 93, QTR 2	001						ND																
ELSD	ACC	VII	CY 93, QTR 3	001						ND																
ELSD	ACC	VII	CY 93, QTR 4	001						ND																
ELSD	ACC	VII	CY 93, QTR 1	002						ND																
ELSD	ACC	VII	CY 93, QTR 2	002						ND																
ELSD	ACC	VII	CY 93, QTR 3	002						ND																
ELSD	ACC	VII	CY 93, QTR 4	002						ND																
ELSD	ACC	VII	CY 93, QTR 1	003						ND																
ELSD	ACC	VII	CY 93, QTR 2	003						ND																
ELSD	ACC	VII	CY 93, QTR 3	003						ND																
ELSD	ACC	VII	CY 93, QTR 4	003						NF																
ELAK	PACAF	X	CY 92, QTR 3	002	2900		150																			ND
ELAK	PACAF	X	CY 92, QTR 3	003	1900		1600																	46		
ELAK	PACAF	X	CY 92, QTR 3	004	910																					
ELAK	PACAF	X	CY 92, QTR 3	007	340		880																			
ELAK	PACAF	X	CY 92, QTR 3	008	2000		67																			
ELAK	PACAF	X	CY 92, QTR 3	010	120																					
FAWA	AMC	X	CY 93, QTR 1	001	340	<20	65																			
FAWA	AMC	X	CY 93, QTR 2	001	1500	110	30																			
FAWA	AMC	X	CY 93, QTR 3	001	70	<2	<10																			
FAWA	AMC	X	CY 93, QTR 4	001	4	<2	169																			
GRND	AMC	VII	CY 93, QTR 1	001		20		1												10		20	5			50
GRND	AMC	VII	CY 93, QTR 2	001		20		1												10		10	5			50
GRND	AMC	VII	CY 93, QTR 3	001		0		0												0		0	0			0
GRND	AMC	VII	CY 93, QTR 4	001		20		1												10		10	5			50
GRND	AMC	VII	CY 93, QTR 1	002		NF		NF												NF		NF	NF			NF
GRND	AMC	VII	CY 93, QTR 2	002		20		1														10	5			50
GRND	AMC	VII	CY 93, QTR 3	002		20		1												10		10	5			50
GRND	AMC	VII	CY 93, QTR 4	002		20		1												10		10	5			50
GRND	AMC	VII	CY 93, QTR 1	003		NF		NF												NF		NF	NF			NF

GRND	AMC	VII	CY 93, QTR 2	003			20		1												10		10	5			50	
GRND	AMC	VII	CY 93, QTR 3	003			20		1												10		10	5			50	
GRND	AMC	VII	CY 93, QTR 4	003			20		1												10		10	5			50	
GRND	AMC	VII	CY 93, QTR 1	040																								
GRND	AMC	VII	CY 93, QTR 2	040																								
GRND	AMC	VII	CY 93, QTR 3	040																								
GRND	AMC	VII	CY 93, QTR 4	040																								
GRND	AMC	VII	CY 93, QTR 1	041																								
GRND	AMC	VII	CY 93, QTR 2	041																								
GRND	AMC	VII	CY 93, QTR 3	041																								
GRND	AMC	VII	CY 93, QTR 4	041																								
GRND	AMC	VII	CY 93, QTR 1	042																								
GRND	AMC	VII	CY 93, QTR 2	042																								
GRND	AMC	VII	CY 93, QTR 3	042																								
GRND	AMC	VII	CY 93, QTR 4	042																								
GRND	AMC	VII	CY 93, QTR 1	043																								
GRND	AMC	VII	CY 93, QTR 2	043																								
GRND	AMC	VII	CY 93, QTR 3	043																								
GRND	AMC	VII	CY 93, QTR 4	043																								
GRND	AMC	VII	CY 93, QTR 1	053																								
GRND	AMC	VII	CY 93, QTR 2	053																								
GRND	AMC	VII	CY 93, QTR 3	053																								
GRND	AMC	VII	CY 93, QTR 4	053																								
GRNY	ACC	II	CY 93, QTR 1	001		234	206	161				66															84	
GRNY	ACC	II	CY 93, QTR 2	001		70	179	<20				30															44	
GRNY	ACC	II	CY 93, QTR 3	001		57	178	80				38															34	
GRNY	ACC	II	CY 93, QTR 4	001		49	187	69				34															56	
GRNY	ACC	II	CY 93, QTR 1	002																								
GRNY	ACC	II	CY 93, QTR 2	002																								
GRNY	ACC	II	CY 93, QTR 3	002																								
GRNY	ACC	II	CY 93, QTR 4	002																								
GRNY	ACC	II	CY 93, QTR 1	003																								
GRNY	ACC	II	CY 93, QTR 2	003																								
GRNY	ACC	II	CY 93, QTR 3	003																								
GRNY	ACC	II	CY 93, QTR 4	003																								
GRNY	ACC	II	CY 93, QTR 1	004																								
GRNY	ACC	II	CY 93, QTR 2	004																								
GRNY	ACC	II	CY 93, QTR 3	004																								
GRNY	ACC	II	CY 93, QTR 4	004																								
GRNY	ACC	II	CY 93, QTR 1	010																								
GRNY	ACC	II	CY 93, QTR 2	010																								
GRNY	ACC	II	CY 93, QTR 3	010																								
GRNY	ACC	II	CY 93, QTR 4	010																								
GRNY	ACC	II	CY 93, QTR 2	020																								
GRNY	ACC	II	CY 93, QTR 3	020																								
GRNY	ACC	II	CY 93, QTR 4	020																								
GRNY	ACC	II	CY 93, QTR 2	021																								
GRNY	ACC	II	CY 93, QTR 3	021																								
GRNY	ACC	II	CY 93, QTR 4	021																								
GRNY	ACC	II	CY 93, QTR 2	022																								
GRNY	ACC	II	CY 93, QTR 3	022																								
GRNY	ACC	II	CY 93, QTR 4	022																								
GRNY	ACC	II	CY 93, QTR 1	030																								
GRNY	ACC	II	CY 93, QTR 2	030																								
GRNY	ACC	II	CY 93, QTR 3	030																								
GRNY	ACC	II	CY 93, QTR 4	030																								
GRNY	ACC	II	CY 93, QTR 1	031																								
GRNY	ACC	II	CY 93, QTR 2	031																								
GRNY	ACC	II	CY 93, QTR 3	031																								
GRNY	ACC	II	CY 93, QTR 4	031																								
GRNY	ACC	II	CY 93, QTR 1	098																								
GRNY	ACC	II	CY 93, QTR 2	098																								
GRNY	ACC	II	CY 93, QTR 3	098																								
GRNY	ACC	II	CY 93, QTR 4	098																								

GRIN	ACC	V	CY 93, QTR 1	002																								
GRIN	ACC	V	CY 93, QTR 2	002																								
GRIN	ACC	V	CY 93, QTR 3	002																								
GRIN	ACC	V	CY 93, QTR 4	002																								
GRIN	ACC	V	CY 93, QTR 1	003																								
GRIN	ACC	V	CY 93, QTR 2	003																								
GRIN	ACC	V	CY 93, QTR 3	003																								
GRIN	ACC	V	CY 93, QTR 4	003																								
GUAL	AETC	IV	CY 92, QTR 3	001																								
GUAL	AETC	IV	CY 92, QTR 4	001																								
GUAL	AETC	IV	CY 93, QTR 1	001																								
GUAL	AETC	IV	CY 93, QTR 2	001																								
GUAL	AETC	IV	CY 93, QTR 3	001																								
GUAL	AETC	IV	CY 92, QTR 3	002																								
GUAL	AETC	IV	CY 92, QTR 4	002																								
GUAL	AETC	IV	CY 93, QTR 1	002																								
GUAL	AETC	IV	CY 93, QTR 2	002																								
GUAL	AETC	IV	CY 93, QTR 3	002																								
GUAL	AETC	IV	CY 92, QTR 3	003																								
GUAL	AETC	IV	CY 92, QTR 4	003																								
GUAL	AETC	IV	CY 93, QTR 1	003																								
GUAL	AETC	IV	CY 93, QTR 2	003																								
GUAL	AETC	IV	CY 93, QTR 3	003																								
GUAL	AETC	IV	CY 92, QTR 3	004																								
GUAL	AETC	IV	CY 92, QTR 4	004																								
GUAL	AETC	IV	CY 93, QTR 1	004																								
GUAL	AETC	IV	CY 93, QTR 2	004																								
GUAL	AETC	IV	CY 93, QTR 3	004																								
KEMI	AETC	IV	CY 93, QTR 3	001			<20		<1.0																			
KEMI	AETC	IV	CY 93, QTR 3	002			27		<1.0														113	<5			214	
KEMI	AETC	IV	CY 93, QTR 3	003			<20																	<5			348	
KEMI	AETC	IV	CY 93, QTR 3	004			<20		<1.0			<50											77	<5			<50	
KEMI	AETC	IV	CY 93, QTR 3	005			<20																	<5			<50	
KEMI	AETC	IV	CY 93, QTR 3	006			25																	<5			<50	
KETX	AFMC	VI	CY 93, QTR 2	002																								
KETX	AFMC	VI	CY 93, QTR 3	002																								
KETX	AFMC	VI	CY 93, QTR 4	002			50					<100									15			<10			545	
KETX	AFMC	VI	CY 93, QTR 3	004			<10					<100															<50	
KETX	AFMC	VI	CY 93, QTR 4	004			30					<100															140	
KETX	AFMC	VI	CY 93, QTR 3	006																								
KETX	AFMC	VI	CY 93, QTR 3	007																								
KETX	AFMC	VI	CY 93, QTR 2	008																								
KETX	AFMC	VI	CY 93, QTR 3	008																								
LIAR	AMC	VI	CY 93, QTR 1	001																								
LIAR	AMC	VI	CY 93, QTR 2	001																								
LIAR	AMC	VI	CY 93, QTR 3	001																								
LIAR	AMC	VI	CY 93, QTR 4	001																								
LIAR	AMC	VI	CY 93, QTR 1	002																								
LIAR	AMC	VI	CY 93, QTR 2	002																								
LIAR	AMC	VI	CY 93, QTR 3	002																								
LIAR	AMC	VI	CY 93, QTR 4	002																								
LIAR	AMC	VI	CY 93, QTR 1	004																								
LIAR	AMC	VI	CY 93, QTR 2	004																								
LIAR	AMC	VI	CY 93, QTR 3	004																								
LIAR	AMC	VI	CY 93, QTR 4	004																								
MAFL	ACC	IV	CY 93, QTR 1	001																								
MAFL	ACC	IV	CY 93, QTR 2	001																								
MAFL	ACC	IV	CY 93, QTR 3	002																								
MAFL	ACC	IV	CY 93, QTR 4	002																								
MAFL	ACC	IV	CY 93, QTR 1	002																								
MAFL	ACC	IV	CY 93, QTR 2	002																								
MAFL	ACC	IV	CY 93, QTR 3	004																								
MAFL	ACC	IV	CY 93, QTR 4	004																								
MAFL	ACC	IV	CY 93, QTR 1	004																								

MAFL	ACC	IV	CY 93, QTR 2	004																								
MAFL	ACC	IV	CY 93, QTR 3	005																								
MAFL	ACC	IV	CY 93, QTR 4	005																								
MAFL	ACC	IV	CY 93, QTR 1	005																								
MAFL	ACC	IV	CY 93, QTR 2	005																								
MAFL	ACC	IV	CY 93, QTR 3	007																								
MAFL	ACC	IV	CY 93, QTR 4	007																								
MAFL	ACC	IV	CY 93, QTR 1	007																								
MAFL	ACC	IV	CY 93, QTR 2	007																								
MAFL	ACC	IV	CY 93, QTR 3	008																								
MAFL	ACC	IV	CY 93, QTR 4	008																								
MAFL	ACC	IV	CY 93, QTR 1	008																								
MAFL	ACC	IV	CY 93, QTR 2	008																								
MAFL	ACC	IV	CY 93, QTR 3	008																								
MAFL	ACC	IV	CY 93, QTR 4	008																								
MAID	AMC	X	CY 93, QTR 3	SP2																								
MAID	AMC	X	CY 93, QTR 4	SP2																								
MAID	AMC	X	CY 93, QTR 3	SP3																								
MAID	AMC	X	CY 93, QTR 4	SP3																								
MAID	AMC	X	CY 93, QTR 3	SP4																								
MAID	AMC	X	CY 93, QTR 4	SP4																								
MAID	AMC	X	CY 93, QTR 3	SP5																								
MAID	AMC	X	CY 93, QTR 4	SP5																								
MAAL	AETC	IV	CY 92, QTR 3	001																								
MAAL	AETC	IV	CY 92, QTR 4	001																								
MAAL	AETC	IV	CY 93, QTR 1	001																								
MAAL	AETC	IV	CY 93, QTR 2	001																								
MAAL	AETC	IV	CY 93, QTR 3	001																								
MAAL	AETC	IV	CY 92, QTR 3	002																								
MAAL	AETC	IV	CY 92, QTR 4	002																								
MAAL	AETC	IV	CY 93, QTR 1	002																								
MAAL	AETC	IV	CY 93, QTR 2	002																								
MAAL	AETC	IV	CY 93, QTR 3	002																								
MAAL	AETC	IV	CY 92, QTR 3	003																								
MAAL	AETC	IV	CY 92, QTR 4	003																								
MAAL	AETC	IV	CY 93, QTR 1	003																								
MAAL	AETC	IV	CY 93, QTR 2	003																								
MAAL	AETC	IV	CY 93, QTR 3	003																								
MAAL	AETC	IV	CY 92, QTR 3	005																								
MAAL	AETC	IV	CY 92, QTR 4	005																								
MAAL	AETC	IV	CY 93, QTR 1	005																								
MAAL	AETC	IV	CY 93, QTR 2	005																								
MAAL	AETC	IV	CY 93, QTR 3	005																								
MAAL	AETC	IV	CY 92, QTR 3	006																								
MAAL	AETC	IV	CY 92, QTR 4	006																								
MAAL	AETC	IV	CY 93, QTR 1	006																								
MAAL	AETC	IV	CY 93, QTR 2	006																								
MAAL	AETC	IV	CY 93, QTR 3	006																								
MAAL	AETC	IV	CY 92, QTR 3	008																								
MAAL	AETC	IV	CY 92, QTR 4	008																								
MAAL	AETC	IV	CY 93, QTR 1	008																								
MAAL	AETC	IV	CY 93, QTR 2	008																								
MAAL	AETC	IV	CY 93, QTR 3	008																								
MCCA	AFMC	IX	CY 93, QTR 4	A								50									14000				<.26	<.37	1000	
MCCA	AFMC	IX	CY 93, QTR 4	Magpie								<50									10000				<.26	<.37	320	
MCCA	AFMC	IX	CY 93, QTR 4	Second								<50									17000				3	<.37	360	
MCCA	AFMC	IX	CY 93, QTR 4	#7								50									22000				<.26	<.37	240	
MIND	ACC	VII	CY 94, QTR 1	Ditch A																								
MIND	ACC	VII	CY 94, QTR 1	Ditch B																								
MIND	ACC	VII	CY 94, QTR 1	NW Ditch																								
MIND	ACC	VII	CY 94, QTR 1	SAC Ramp																								
PAFL	SPCM	IV	CY 93, QTR 2	18"																								
PAFL	SPCM	IV	CY 93, QTR 3	18"																								
PAFL	SPCM	IV	CY 93, QTR 4	18"																								

PAFL	SPCM	IV	CY 94, QTR 1	18"	
PAFL	SPCM	IV	CY 93, QTR 2	36"	
PAFL	SPCM	IV	CY 93, QTR 3	36"	
PAFL	SPCM	IV	CY 93, QTR 4	36"	
PAFL	SPCM	IV	CY 94, QTR 1	36"	
PAFL	SPCM	IV	CY 93, QTR 2	54"	
PAFL	SPCM	IV	CY 93, QTR 3	54"	
PAFL	SPCM	IV	CY 93, QTR 4	54"	
PAFL	SPCM	IV	CY 94, QTR 1	54"	
PAFL	SPCM	IV	CY 93, QTR 2	Fire	
PAFL	SPCM	IV	CY 93, QTR 3	Fire	
PAFL	SPCM	IV	CY 93, QTR 4	Fire	
PAFL	SPCM	IV	CY 94, QTR 1	Fire	
PAFL	SPCM	IV	CY 93, QTR 2	POL	
PAFL	SPCM	IV	CY 93, QTR 3	POL	
PAFL	SPCM	IV	CY 93, QTR 4	POL	
PAFL	SPCM	IV	CY 94, QTR 1	POL	
RETX	AETC	VI	CY 94, QTR 2	001	
RETX	AETC	VI	CY 94, QTR 2	002	
RETX	AETC	VI	CY 94, QTR 2	003	
RETX	ACC	IV	CY 93, QTR 1	002	
SHSC	ACC	IV	CY 93, QTR 2	002	
SHSC	ACC	IV	CY 93, QTR 3	002	
SHSC	ACC	IV	CY 93, QTR 4	002	
SHSC	ACC	IV	CY 93, QTR 1	003	
SHSC	ACC	IV	CY 93, QTR 2	003	
SHSC	ACC	IV	CY 93, QTR 3	003	
SHSC	ACC	IV	CY 93, QTR 4	003	
TIOK	AFMC	VI	CY 93, QTR 1	002	
TIOK	AFMC	VI	CY 93, QTR 2	002	
TIOK	AFMC	VI	CY 93, QTR 3	002	
TIOK	AFMC	VI	CY 93, QTR 4	002	
TIOK	AFMC	VI	CY 93, QTR 1	006	
TIOK	AFMC	VI	CY 93, QTR 2	006	
TIOK	AFMC	VI	CY 93, QTR 3	006	
TIOK	AFMC	VI	CY 93, QTR 4	006	
TIOK	AFMC	VI	CY 93, QTR 1	007	
TIOK	AFMC	VI	CY 93, QTR 2	007	
TIOK	AFMC	VI	CY 93, QTR 3	007	
TIOK	AFMC	VI	CY 93, QTR 4	007	
TIOK	AFMC	VI	CY 93, QTR 1	008	
TIOK	AFMC	VI	CY 93, QTR 2	008	
TIOK	AFMC	VI	CY 93, QTR 3	008	
TIOK	AFMC	VI	CY 93, QTR 4	008	
TIOK	AFMC	VI	CY 93, QTR 1	009	
TIOK	AFMC	VI	CY 93, QTR 2	009	
TIOK	AFMC	VI	CY 93, QTR 3	009	
TIOK	AFMC	VI	CY 93, QTR 4	009	
WEMA		I	CY 93, QTR 1	001	
WEMA		I	CY 93, QTR 2	001	
WEMA		I	CY 93, QTR 4	001	
WEMA		I	CY 93, QTR 1	002	
WEMA		I	CY 93, QTR 2	002	
WEMA		I	CY 93, QTR 4	002	
WROH	AFMC	V	CY 93, QTR 1	001	
WROH	AFMC	V	CY 93, QTR 2	001	
WROH	AFMC	V	CY 93, QTR 3	001	
WROH	AFMC	V	CY 93, QTR 4	001	
WROH	AFMC	V	CY 93, QTR 1	002	
WROH	AFMC	V	CY 93, QTR 2	002	
WROH	AFMC	V	CY 93, QTR 3	002	
WROH	AFMC	V	CY 93, QTR 4	002	
WROH	AFMC	V	CY 93, QTR 1	003	1755
WROH	AFMC	V	CY 93, QTR 2	003	370

WROH	AFMC	V	CY 93, QTR 3	003	906																						
WROH	AFMC	V	CY 93, QTR 4	003	193																						
WROH	AFMC	V	CY 93, QTR 1	004	340																						
WROH	AFMC	V	CY 93, QTR 2	004	70																						
WROH	AFMC	V	CY 93, QTR 3	004	80																						
WROH	AFMC	V	CY 93, QTR 4	004	73																						
WROH	AFMC	V	CY 93, QTR 1	005																							
WROH	AFMC	V	CY 93, QTR 2	005																							
WROH	AFMC	V	CY 93, QTR 3	005																							
WROH	AFMC	V	CY 93, QTR 4	005																							
WROH	AFMC	V	CY 93, QTR 1	006																							
WROH	AFMC	V	CY 93, QTR 2	006																							
WROH	AFMC	V	CY 93, QTR 3	006																							
WROH	AFMC	V	CY 93, QTR 4	006																							
			data		22	33	12	19	1	12	16	2	2	2	2	2	2	2	0	20	0	18	22	12	4	33	
			#s		22	23	10	10	1	0	7	0	0	0	0	0	0	0	0	15	0	12	11	2	0	28	
					0.50	0.26	0.90	0.00	1.00	ERR	0.00	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	0.40	ERR	0.17	0.91	0.00	ERR	0.50	

Appendix H: Acronyms and Abbreviations

ACC	Air Combat Command
AETC	Air Education and Training Command
AF	Air Force
AFMC	Air Force Material Command
AFRES	Air Force Reserves
AMC	Air Mobility Command
BOD	Biological Oxygen Demand
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
COD	Chemical Oxygen Demand
CWA	Clean Water Act
EPA	Environmental Protection Agency
mg/L	Milligrams per liter
N+N	Nitrate and Nitrite
ND	None Detected
NF	No Flow
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
O&G	Oils and Grease
P	Total Phosphorus
PACAF	Pacific Air Force
PCB	Polychlorinated Biphenyl
ppm	Parts per million
POTWs	Publicly-Owned Treatment Works
SIC	Standard Industrial Classification
SPCC	Spill Prevention, Control and Countermeasures
SPCOM	Space Command
SWPPP	Storm Water Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
U.S.	United States
ug/L or µg/L	Micrograms per liter
USEPA	United States Environmental Protection Agency

Bibliography

Air & Water Pollution: A Compliance Manual. Neenah, Wisconsin: J.J. Keller & Associates, Inc., 1992, 1993.

A National Water Agenda for the 21st Century (Water Quality 2000 Final Report). Alexandria, Virginia: Water Environment Federation, 1992.

Alexander, G.R. "Best Management Practices for Nonpoint Source Control," in Proceedings of the Best Management Practices for Nonpoint Source Pollution Control Seminar. 3-5. Chicago, Illinois: USEPA, 1976.

Arbuckle, J. Gordon. "Water Pollution Control," in Environmental Law Handbook. Rockville, MD: Government Institutes, Inc., 1993.

Bishop, Jim. "Confusion Reigns Over Industrial Stormwater Regulations," Hazmat World, 6(1): 38-39 (January 1993).

Bromley, Eugene. Environmental Engineer, Storm Water Coordinator, U.S. Environmental Protection Agency, San Francisco, CA. Conference handout, Stormwater Permitting and Compliance I, University Extension, University of California, Davis, May 26, 1992.

Chinn, Stephen and Martha Crow. "The Gathering Storm," American City and Country: 38-54 (July 1993).

Combs, Johnny D. Environmental Engineer, Air Force Center For Environmental Excellence, Regional Compliance Office, Dallas, TX. Telephone interview. 29 June 1994.

Dodson, Roy D. Storm Water Pollution Control: Industry and Construction NPDES Compliance. To be Published, McGraw-Hill, 1994.

El-Naggar, A. Sami. "Field Sampling and Analysis of Industrial Stormwater Discharges," Water Engineering & Management: 15-17 (February 1992).

Ember, Lois R. "Clean Water Act is Sailing a Choppy Course to Renewal," C&EN: 18-24, (February 17, 1992).

Goddish, Thad. Air Quality. Chelsea, Michigan: Lewis Publishers, 1991.

Kodukula, P.S. "Stormwater Pollution Prevention Programs," Environmental Protection: 54-61 (September 1993).

Kovalic, Joan M. "The Clean Water Act of 1987," Water Environment Federation, 1987.

Masters, Gilbert M. Introduction to Environmental Engineering and Science. Englewood Cliffs, New Jersey: Prentice Hall, 1991.

Miller, Ralph and Norman D. Webb. "Addressing Storm Water Treatment," Scrap Processing & Recycling, 48(4): 91-94 (July-August 1991).

Novotny, Vladmir and Gordon Chesters. Handbook of Nonpoint Pollution. New York: Van Nostrand Reinhold Company, 1981.

Roy, Kimberly A. "Nonpoint Source Pollution," Hazmat World, 4: 66-67 (July 1991).

U.S. Environmental Protection Agency. Air Quality Criteria for Particulate Matter and Sulfur Oxides, final draft. 1981.

-----. Nonpoint Source Pollution in the U.S. Washington: GPO, January 1984.

-----. The Quality of Our Nation's Water: 1992. Washington: GPO, March 1993a.

-----. "Fact Sheet For the Multi-Sector Stormwater General Permit," Federal Register, 58(222): 61146-61449 (Friday, November 19, 1993)b.

-----. "NPDES General Permit for Storm Water Discharges From Industrial Activities," Federal Register, 58(222): 61450-61596 (Friday, November 19, 1993)c.

-----. The Quality of Our Nation's Water: 1992. Washington: GPO, March 1994.

U.S. Government Accounting Office. Water Pollution: Greater EPA Leadership Needed to Reduce Nonpoint source Pollution. Washington: GPO, October 1990.

Weldon II, Jerry K. and Roy T. Willis. Guidance For The Development Of Air Force Storm Water Sampling Programs. MS thesis, AFIT/GEE/ENV/93S-18. School of Engineering, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, September 1993.

Wilmer, Ralph R. "The Role of Watershed Protection Planning and the Surface Water Treatment Rule," The Environmental Professional, 14(2): 126-135 (1992).

Vita

Lynne A. Urquhart was born on September 13, 1967 at Vandenburg AFB, California. She graduated from Woodbridge Senior High School in Woodbridge, Virginia in 1985 and attended the University of South Alabama in Mobile, Alabama, graduating with a Bachelor of Science in Civil Engineering in June 1991. Upon graduation, she accepted an intern position with the civil service at Pope AFB, North Carolina. She was then selected to attend the School of Engineering at the Air Force Institute of Technology in May 1994. Upon graduation she will be working in the IRP program at Langley AFB, Virginia.

Permanent Address:
2294 Zink Road, Apt. #4
Fairborn, OH 45324

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
September 1994

3. REPORT TYPE AND DATES COVERED
Master's Thesis

4. TITLE AND SUBTITLE
STATUS OF STORM WATER POLLUTION IN THE UNITED STATES

5. FUNDING NUMBERS

6. AUTHOR(S)
Lynne A. Urquhart

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology, WPAFB OH. 45433-6583

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GEE/ENV/94S-25

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The purpose of this study was to determine the status of storm water pollution in the United States Air Force. This is important since most AF bases are now required to have applied for a NPDES storm water permit. The objectives of the study were to: evaluate the sampling rates used at AF bases; determine the pollutants tested for by the AF bases; compare the pollutant concentrations of the AF bases to an EPA water quality standard; and determine if there were any trends in sampling or pollutant concentrations due to seasonal changes or across AF Commands or EPA Regions. This was done by requesting data from eighty-one AF bases in the United States. Data was received from fifty bases. This data shows that the AF has a problem with its storm water. There were seventeen pollutants for which the AF was evaluated. One pollutant (TKN) is not a problem, four (pH, lead, phosphorus, and TSS) of the pollutants present a problem only at individual bases, and the other twelve pollutants are significant problem for the AF. The AF data exceeded the bench mark values for the other twelve pollutants at rates ranging from thirteen percent for aluminum up to ninety-six percent for copper. There were no trends in pollutant concentrations across EPA Regions. The only trend across the AF commands was that ACC is the only command with lower a percentage of data exceeding the bench mark values than the AF as a whole for most pollutants.

14. SUBJECT TERMS
Storm Water, National Pollutant Discharge Elimination System (NPDES), United States Air Force

15. NUMBER OF PAGES
103

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL